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EDITORS

A. Scott Warthin, for The Paleontological Society.

J. Marvin Weller, for The Society of Economic Paleontologists and Mineralogists.

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VOLUME 23 NOVEMBER, 1949 NUMBER 6

FOSSIL AND RECENT SPECIES OF THE PELECYPOD GENERA *CHIONE* AND *SECURELLA* FROM THE PACIFIC COAST[1]

PIERRE PARKER
Washington, D. C.

ABSTRACT—Thirty-four species, one subspecies and five varieties of chionid pelecypods from the Tertiary and Recent faunas of the Pacific Coast of North America are discussed and figured. Nineteen species, the subspecies and all the varieties are referred to the genus *Chione*, with the subgenera *Chione s.s.*, *Anomalocardia*, and the new subgenus *Gnidiella*. The remaining 13 species are referred to the new genus *Securella*. The genus *Chione* is apparently of neotropical origin, first appearing in California during the Temblor Miocene. In the Recent fauna the genus *Chione* ranges from Point Conception, California, to Peru, but during the Pleistocene it ranged as far north as Tomales Bay, California. The new genus *Securella*, in contrast to *Chione*, appears to have a North Pacific origin, first appearing in the upper Oligocene of central California, Washington and Alaska, and becoming extinct in the Pliocene. The geographic distribution of *Securella* is from the Transverse Ranges of southern California north to Alaska and westward to Kamchatka. The species often referred to as *Chione fluctifraga* and *C. columbiensis* appear to be better referred to the genus *Protothaca*.

INTRODUCTION

THIS paper is an attempt to monograph the chiones of the Pacific Coast of North America. Many of the species are closely related to those of the Caribbean region, but lack of time and material prevented the inclusion of Caribbean forms in this discussion. In the California region chiones are found with sufficient frequency in the stratigraphic record to serve as valuable horizon markers and as a result they deserve careful examination to prevent any misunderstanding of their stratigraphic value. This is particularly important since many species have been described from poorly preserved and distorted individuals, resulting in an unnecessary number of names.

In the course of the investigation it became evident that a large number of fossil species, hitherto referred to the genus *Chione*, formed in themselves a closely related group. Because of the fact that this group has not only a different point of origin than the genus *Chione* but a different range geologically as well as geographically, and in addition special features of hinge and sculpture, it became desirable to recognize the group under the new generic name of *Securella*. Since both genera make their first appearance in widely separated areas of North America at about the same time, there is no reason to believe that they are more closely related than any other genera of the Veneridae.

[1] A Contribution from the Museum of Paleontology of the University of California, Berkeley, California.

The West Coast species here referred to *Chione* are classified among three subgenera: *Anomalocardia*, *Chione s.s.*, and the new subgenus *Gnidiella*. These subgenera do not correspond to those used by Palmer.[2] The subgenus *Chione* of that paper has been divided into *Chione* and *Gnidiella*, while the present *Anomalocardia* includes part of her *Lirophora*.

Among the Recent species, too, there has been found need for considerable revision. Dall,[3] for example, reported *Chione subrostrata*, a Caribbean species, from Mazatlan to Peru, yet not a single authentic specimen of this species from the Pacific Coast can be found in collections of West Coast museums.

The conclusions drawn here are the result of intensive study of many hundreds of specimens. Several types have been further cleaned and refigured, and new topotype material prepared.

Dental armature is the primary basis for classification of the Pelecypoda, but the author feels that this has not been sufficiently stressed in dealing with the smaller categories such as subgenera and species. That the hinge is a much more conservative structure than the surface ornamentation is generally accepted; therefore it is only reasonable that surface sculpture should be used only after the last inference has been drawn from the hinge. In consequence the classification presented here is based primarily upon the character of the hinge and ligament, while the shape and ornamentation has been utilized in the differentiation of species and smaller units.

The author wishes to express his thanks to the late Dr. B. L. Clark for guidance in the preparation of this paper. His indebtedness is also acknowledged to Drs. J. W. Durham, L. G. Hertlein, A. M. Keen, and G. E. MacGinitie.

Assistance in the preparation of these materials was furnished by the personnel of the Works Projects Administration, Official Project No. 65-1-08-62, Unit A-1.

[2] Palaeontographica Americana, vol. 1, no. 5, p. 139, 1926.

[3] Proc. U. S. Nat. Mus., vol. 26, p. 393, 1902.

ECOLOGY

Living species of *Chione* usually are found in the comparatively shallow waters of bays and lagoons. However, *Chione kellettii* has been dredged from 100 fathoms off Lower California. Chiones are often found in large numbers just below the mean low tide line, and at times more than one species may live at the same locality.

EXPLANATION OF PLATE 89

FIG. *1*—*Chione* (*Chione*) *undatella* (Sowerby) *s.s.* (×0.8). Hypotype Stanford Univ. Paleo. Type Coll. no. 5968. Recent, "Lower California." (p. 582)

2, *5*, *6*—*C.* (*C.*) *metadon* Pilsbry and Lowe. Hypotype C.A.S. no. 7788. Recent, West Coast of Mexico. *2*, (×0.65); *5*, *6*, (×1). (p. 581)

3—*C.* (*C.*) *compta* (Broderip) (×1.3). Hypotype U. S. Nat. Mus. no. 131508. Recent, Payta, Peru. (p. 581)

4—*Securella ensifera* (Dall). (×1.3). Hypotype C.A.S. no. 5976, C.A.S. loc. 913. Miocene of Washington. An example of hinge of *Securella*. (p. 590)

7—*Protothaca fluctifraga* (Sowerby) (×2). Hypotype Stanford Univ. Paleo. Type Coll. no. 6957. Recent, Almejos Bay, Lower California. (p. 593)

8—*Chione* (*Gnidiella*) *amathusia* (Philippi) (×1.3). Hypotype no. 36081, loc. 2404. Recent, Gulf of California. An example of hinge of subgenus *Gnidiella*. (p. 582)

9—*C.* (*Chione*) *cancellata* (Linneaus) (×0.85). Hypotype no. 36101, loc. 6113. Recent, West Indies. Genotype of *Chione*. (p. 580)

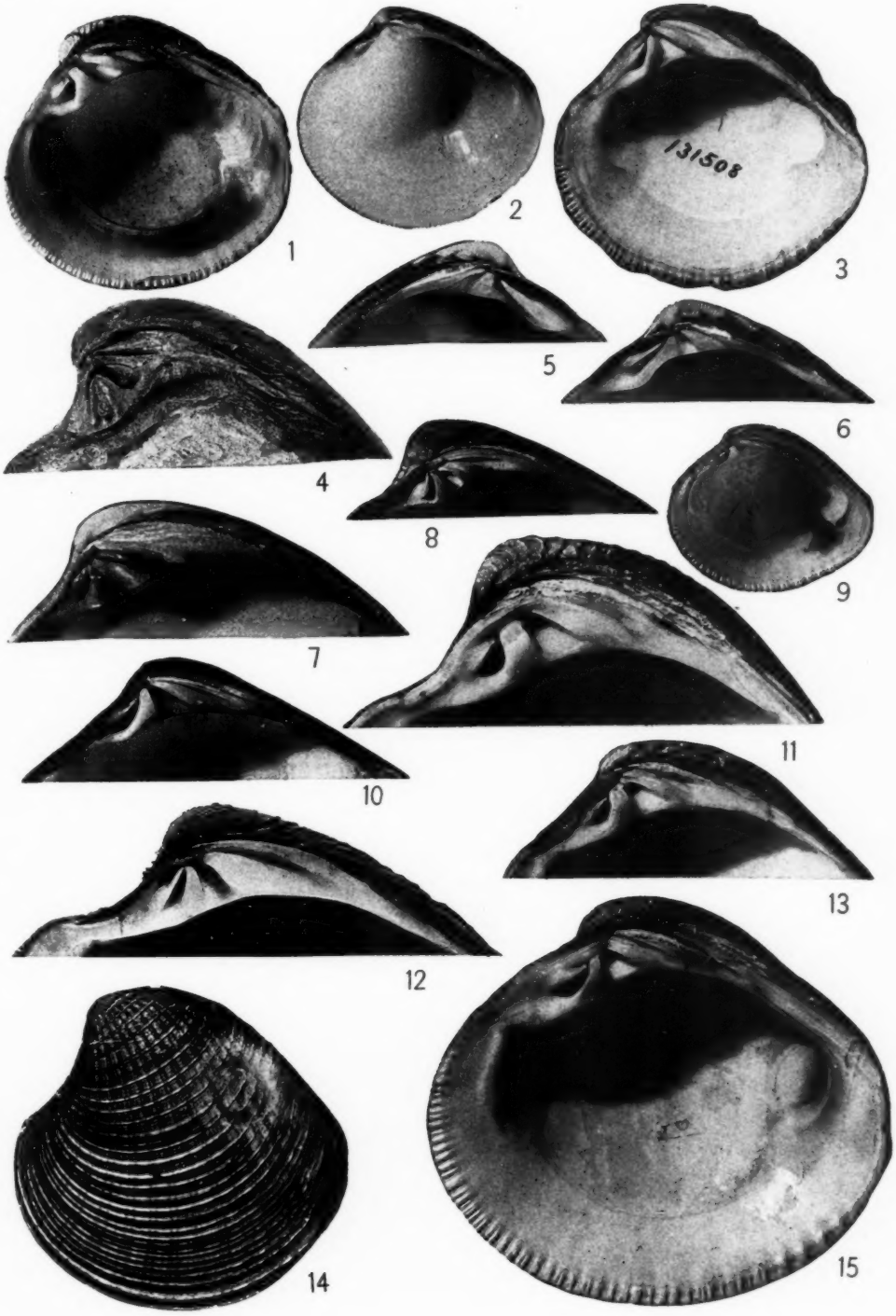
10—*C.* (*Anomalocardia*) *subrugosa* (Sowerby) (×1.3). Hypotype no. 36089, loc. 2404. Recent, Gulf of California. An example of hinge of *Anomalocardia*. (p. 587)

11, *14*—*C.* (*Chione*) *californiensis* (Broderip) *s.s.* *11*, (×1.3), hypotype no. 36072, loc. 2392. Recent, San Diego, California. *14*, (×0.8), hypotype no. 36073, same loc. as fig. *11*. (p. 580)

12—*C.* (*Gnidiella*) *gnidia* (Broderip and Sowerby) (×1.3). Hypotype no. 36083, loc. 2416. Recent, Panama. (p. 583)

13—*C.* (*Chione*) *californiensis* (Broderip) var. *gealyi* Parker, n. var. (×0.8). Holotype no. 36074, loc. 1657. Recent, Mission Bay, California. (p. 580)

15—*C.* (*C.*) *undatella* subsp. *simillima* (Sowerby) (×1.3). Hypotype no. 36079, loc. 1668. Recent, San Diego, California. (p. 582)



Parker, Fossil and Recent Pelecypoda

Parker, Fossil and Recent Pelecypoda

A collection of live specimens from a small intertidal area in Mission Bay, California, consisted of some 200 individuals of various sizes. These were found to include two species, *Chione undatella* subsp. *simillima*, and *Chione californiensis* var. *gealeyi*, in equal numbers. In view of the obviously close resemblance between these two species and the striking fact that no intermediate forms were present, the possibility of sexual dimorphism was considered. A subsequent investigation, however, proved this not to be the case as both sexes were found in each morphologic group.

In California, *Protothaca staminea*, *P. fluctifraga* and *Macoma nasuta* are commonly found living in association with *Chione undatella* and *C. californiensis*.

DISTRIBUTION

The subgenera *Chione*, *Gnidiella* and *Anomalocardia* are probably of neotropical origin. Their present distribution is limited to warm waters. The subgenus *Chione* finds its northern boundary at Point Conception (latitude 34°25′ N.), *Gnidiella* and *Anomalocardia* at Cedros Island, Lower California (latitude 28°12′ N.). All three subgenera are abundant from the Gulf of California to Panama. Peru seems to be the southernmost occurrence reported for the genus *Chione*, although the records are scarce.

The genus *Securella* appears to have its greatest abundance in the region from northern California north to Washington, but has been recorded as far south as the Transverse Ranges in southern California (latitude 34°30′ N.), northward to the Gulf of Alaska (latitude 60° N.), and westward from there to Kamchatka.

GEOLOGIC RANGE

The subgenera *Gnidiella* and *Anomalocardia* first appear in California during the Temblor Miocene. At that time *Gnidiella* extended as far north as the southern San Joaquin Valley, somewhat further north than at any later time. The subgenus *Chione s. s.* did not appear in California proper until late Pliocene or early Pleistocene. In the Pleistocene it ranged as far north as Tomales Bay. The genus *Securella* is first recorded in the upper Oligocene of Alaska, Washington and California, and appears to have become extinct during the upper Pliocene. It is also known from the Miocene-Pliocene of Kamchatka.

SYSTEMATIC DESCRIPTION

In the following descriptions of species, the conventional method of completely describing each species has been dispensed with. Instead each species is compared to the subgeneric description and only those points in which they differ from the typical are mentioned. It is hoped that the illustrations may adequately replace written descriptions.

EXPLANATION OF PLATE 90

FIGS. *1, 5, 11*—*Chione* (*Chione*) *californiensis* (Broderip) var. *peabodyi* Parker, n. var. (×0.80). *1*, holotype no. 36076; *5*, paratype no. 36078; *11*, paratype no. 36077. Loc. 7086, Pleistocene. (p. 581)

2, 4, 9—*C.* (*C.*) *undatella* (Sowerby) var. *taberi* Parker (×0.75). *2, 4, 9*, holotype no. 36080; from loc. 2897. Recent, Gulf of California. (p. 582)

3—*C. californiensis* (Broderip) var. *durhami* Parker, n. var. (×0.75). Holotype C.A.S. no. 5977, loc. 27242. Recent, Espiritu Island, Gulf of California. (p. 581)

6, 8—*C.* (*C.*) *compta* (Broderip) (×1). Hypotype U. S. Nat. Mus. no. 131508, Recent, Payta, Peru. (p. 581)

7, 10—*C.* (*C.*) *californiensis* (Broderip) var. *gealeyi* Parker, n. var. (×1.25). Holotype no. 36074, loc. 1657. Recent, Mission Bay, California. (p. 580)

12, 13—*C.* (*C.*) *undatella* (Sowerby) *s.s.* (×0.80). Hypotype Stanford Univ. Paleo. Type Coll. no. 6958. Recent, Lower California. (p. 581)

14—*C.* (*C.*) *compta* (Broderip) var. *meridionalis* Oldroyd (×1). Holotype no. 31206, loc. 3135. Recent, Sechura Bay, Peru. (p. 581)

15, 16—*C.* (*C.*) *undatella* (Sowerby) subsp. *simillima* (Sowerby) (×1.2). Hypotype no. 36079, loc. 1668, Recent, San Diego, California. (p. 582)

Genus CHIONE Megerle von Muhlfeld

Chione MEGERLE VON MUHLFELD 1811, Mag. Ges. Naturf. Freunde zu Berlin, v. 5, p. 51.
Chiona MÖRCH 1853, Cat. Conch. Yoldi, p. 24.
Chione, DESHAYES 1853, Cat. Conch. Brit. Mus., pt. 1, p. 118.
Chione, GRANT and GALE 1931, Mem. San Diego Soc. Nat. Hist. v. 1, p. 318.
Genotype *Venus dysera* Chemnitz = *Venus cancellata* Linnaeus. Living, Cape Hatteras to Trinidad. (Plate 91, figs. 3, 4.)

Shell more or less trigonal because of prominent beak; lunule and escutcheon well defined; escutcheon with faint concentric ribbing or smooth; sculpture of lunule similar to that of shell; crenulations along inner margin of ventral half of shell and on margin of lunule; hinge plate of each valve with only three teeth; middle cardinal of left valve may be grooved; middle and posterior cardinals of right valve sometimes slightly grooved; both radial and concentric ribs present but radial ribbing may be obscured or obliterated by overlying concentric ribs; pallial sinus usually short and rounded.

The chief morphologic basis for the separation of *Chione* from the new genus *Securella* lies in the position of the ligament and shape of the pallial sinus. In *Chione* the ligament barely penetrates the valve to meet the nymph plate while in *Securella* it is deeply sunken in the valve and extends well across the hinge before abutting against the nymph plate.

Subgenus CHIONE *s. s.*

Teeth smooth except for slight grooves on steep face toward the umbones; right anterior cardinal reduced or absent; right middle cardinal wide; pallial sinus almost absent; sculpture of radial and concentric ribs.

The hinge of *Chione* (*Chione*) *undatella* subsp. *simillima* (Sowerby) (Pl. 89, fig. 15) is characteristic of the Pacific Coast members of this subgenus.

Chione (*Chione*) *californiensis* (Broderip)
Plate 89, figures 11, 14

Venus succincta VALENCIENNES 1833, in Humboldt and Bonpland, Recueil d'Obser. Zool. vol. 2, p. 219; figured in Atlas to vol. 2, 1811. Not *Venus succincta* Linne 1771, Mantissa 2, p. 546.
Venus californiensis BRODERIP 1835, Proc. Zool. Soc. London, p. 43; Sowerby 1855, Thes. Conch. vol. 2, p. 711, pl. 154, figs. 40, 41.
Venus nuttalli CONRAD 1837, Jour. Acad. Nat. Sci. Phil. vol. 7, p. 251, pl. 19, fig. 16, not fig. 14.
Chione succincta, GABB, 1869, Geol. Surv. Calif. Paleo. vol. 2, p. 94.
Chione (*Chione*) *succincta*, DALL, 1902, Proc. U.S. Nat. Mus. vol. 26, p. 392.
Venus (*Chione*) *succincta*, GRANT and GALE, 1931 (in part) Mem. San Diego Soc. Nat. Hist. vol. 1, p. 321, pl. 16, fig. 1–4.

Anterior cardinal of right valve almost lost and fused to lunular margin of shell; middle cardinal very wide with its sides almost parallel; top surface of this tooth flat so that dorsal and ventral slopes meet in a ridge about midway; in left valve anterior cardinal straight; middle cardinal with parallel sides and slightly grooved dorsal slope; sculpture of lunule predominantly radial.

C. californiensis may be distinguished from *C. undatella* not only by the above features but also by the concentric ribs which thicken and recurve umbonally. In general, there is a tendency to obsolescence of the concentric ribs at the umbonal end and also posteriorly.

Dimensions.—Hypotype no. 36072, length 58 mm., height 56 mm.

Hypotypes.—Nos. 36072, 36073,[4] loc. 2392, San Diego, California.

Distribution.—Recent, San Pedro, California, to Panama; Pleistocene of San Pedro, California; late Pliocene and early Pleistocene of Gulf of California region.

The above description applies only to *Chione* (*C.*) *californiensis s.s.*

CHIONE (C.) CALIFORNIENSIS var. GEALEYI Parker, n. var.
Plate 89, figure 13; plate 90, figure 7, 10

Characterized by a reduction in number of concentric ribs and their disappearance posteriorly; shell outline noticeably longer than high.

Dimensions of holotype.—Length 40 mm., height 35 mm.

Holotype.—No. 36074, paratype no. 36075, loc. 1657, Mission Bay, San Diego, California.

Distribution.—Recent; Pt. Conception to Guaymas, Gulf of California.

[4] Unless otherwise noted, all specimen and locality numbers refer to the collections in the Museum of Paleontology, University of California, Berkeley, California.

CHIONE (C.) CALIFORNIENSIS var. DURHAMI Parker, n. var.
Plate 90, figure 3

Distinguished by very thin concentric ribs crenulated by radial ribs; concentric ribs completely developed from anterior to posterior margins; ventrally on adult shells they recurve umbonally to overlap preceding rib.

Dimensions.—Length 70 mm., height 65 mm.

Holotype.—Cal. Acad. Sci. Paleo. Type Coll. no. 5977, C.A.S. loc. 27242, Espiritu Island, Gulf of California.

Distribution.—Recent, San Pedro, California, to Panama. Pleistocene of San Pedro, California. Late Pliocene and early Pleistocene of Gulf of California region.

CHIONE (C.) CALIFORNIENSIS var. PEABODYI Parker, n. var.
Plate 90, figures 1, 5, 11

Characterized by a particularly heavy hinge plate with much reinforcing material between teeth; in mature individuals umbonal ends of sockets completely filled and even part of the teeth are covered; concentric ribs recurve anteriorly at an early stage and on younger portions of shell even coalesce; shell outline variable.

Dimensions of holotype.—Length 63 mm., height 59 mm.

Holotype.—No. 36076, paratypes nos. 36077, 36078, all from loc. 7086 (large canyon one-half mile north of Springville, Ventura County, California). Pleistocene.

Distribution.—Pleistocene: Saugus formation of Santa Barbara County; late Pliocene and early Pleistocene of the Gulf of California and the Galapagos Islands.

CHIONE (CHIONE) COMPTA (Broderip)
Plate 89, figure 3; plate 90, figures 6, 8

Venus compta BRODERIP, 1835, Proc. Zool. Soc. London, p. 43.
Chione (*Chione*) *compta*, DALL, 1902. Proc. U. S. Nat. Mus. vol. 26, p. 393.

Hinge same as that of *Chione undatella simillima*, but much flatter; concentric ribs very thick, evenly and widely separated

Dimensions.—Length 60 mm., height 53 mm. (large mature shell).

Hypotype.—U. S. Nat. Mus. no. 131508, Payta, Peru.

Distribution.—Recent, Gulf of California to Peru.

CHIONE (C.) COMPTA var. MERIDIONALIS Oldroyd
Plate 90, figure 14

Chione meridionalis OLDROYD, 1921, Nautilus, vol. 34, p. 93, pl. 4, figs. 3, 4.

Normal concentric ribs in part replaced by low rounded swellings. Dimensions and distribution same as the typical form.

Holotype.—No. 31206, Recent, Sechura Bay, Peru.

CHIONE (CHIONE) METADON Pilsbry and Lowe
Plate 89, figures 2, 5, 6; plate 91, figures 5, 6

Chione metadon PILSBRY and LOWE, 1931, Proc. Acad. Nat. Sci. Phil. vol. 84, p. 100, pl. 15, figs. 10, 11.

Distinctive in possessing unusually long anterior cardinals.

Dimensions of hypotype.—(C. A. S. Paleo. Type Coll. no. 7788), length 55 mm., height 50 mm.

Holotype.—Acad. Nat. Sci. Phil. no. 155571.

Hypotype.—Calif. Acad. Sci. no. 7788, Recent, West Coast of Mexico.

Distribution.—Recent, Gulf of California to Panama.

CHIONE (CHIONE) UNDATELLA (Sowerby)
Plate 89, figure 1; plate 90, figures 12, 13

Venus undatella SOWERBY, 1835, Proc. Zool. Soc. London p. 22; 1855, Thes. Conch. vol. 2, p. 711, pl. 153, fig. 22.
Venus neglecta SOWERBY, 1839, Zool. Beechey's Voy. Blossom, p. 151, pl. 41, fig. 8.
Chione undatella, VERRILL, 1870, Amer. Jour. Sci. and Arts, 2nd series, vol. 49, pp. 224–225.
Chione (*Chione*) *undatella*, DALL, 1902, Proc. U. S. Nat. Mus., vol. 26, p. 392.
Venus (*Chione*) *succincta*, GRANT and GALE, 1931 (in part), Mem. San Diego Soc. Nat. Hist. vol. 1, p. 321, pl. 16, figs. 1–4.

Lunule faintly sculptured with predominantly concentric ribs; right and left middle cardinals with dorsal slopes much shorter than ventral slopes, producing a more pointed tooth than in *C.* (*C.*) *californiensis.*

Dimensions.—Length 50 mm., height 48 mm. (average mature shell).

Hypotype.—L. S. J. U. no. 6958, locality unknown.

Distribution.—Recent, Cedros Island, Lower California, to Panama. Pleistocene; San Pedro, California. Late Pliocene and early Pleistocene of the Gulf of California and the Galapagos Islands.

CHIONE (C.) UNDATELLA subsp. SIMILLIMA (Sowerby)

Plate 89, figure 15; plate 90, figures 15, 16

Venus simillima SOWERBY, 1855, Thes. Conch. vol. 2, p. 708, pl. 153, fig. 17, not 18.

Distinguished from *C.* (*C.*) *undatella s.s.* by right middle cardinal having its anterior side strongly curved so that width of tooth measured along the edge of the hinge plate is greater than length of tooth measured from edge of hinge plate to umbo; without surface color markings as in *C.* (*C.*) *undatella s.s.*; outline generally longer.

Dimensions.—Length 58 mm., height 51 mm.

Hypotype.—No. 36079, loc. 1668, Mission Bay, California.

Distribution.—Recent, San Pedro, California, to Cedros Island, Lower California. Pleistocene: Saugus formation of Santa Barbara County and of Tomales Bay, California.

CHIONE (C.) UNDATELLA var. TABERI Parker, n. var.

Plate 90, figures 2, 4, 9

Distinguished by flatness of valves, and more evenly and widely spaced concentric ribs; hinge intermediate between *C.* (*C.*) *undatella s.s.* and *C.* (*C.*) *undatella simillima.*

Dimensions of holotype.—Length 39 mm., height 35 mm., thickness (both valves) 19 mm.

Holotype.—No. 36080, loc. 2897, Gulf of California. Recent.

Distribution.—Recent, Gulf of California.

Subgenus GNIDIELLA Parker, n. subgenus
Subgenotype: *Venus gnidia* Broderip and Sowerby

Right and left anterior cardinals thin but large, rising from floor of hinge plate rather than from the margin of shell as in other subgenera; right posterior cardinal wide and broadly grooved; left middle cardinal large and grooved; sculpture of both radial and concentric ribs. Hinge illustrated on Pl. 89, fig. 12.

Gnidiella: from *gnidia*, the specific name of the subgenotype.

CHIONE (GNIDIELLA) AMATHUSIA (Philippi)

Plate 89, figure 8; plate 91, figures 10, 12, 14

Venus amathusia PHILIPPI, 1844, Abbild. Beschr. Conchyl., vol. 1, Venus tab., p. 129, fig. 4.
Chione amathusia, DALL, 1902, Proc. U. S. Nat. Mus., vol. 26, p. 394.

Close to *C. gnidia* but distinguished by longer and straighter posterior margin; concentric ribs thicker, not as high, and much closer together.

EXPLANATION OF PLATE 91

FIGS. *1, 8, 11*—*Chione* (*Gnidiella*) *gnidia* (Broderip and Sowerby) (×0.66). *1, 8, 11*, hypotype no. 36083; from loc. 2416. Recent, Panama. (p. 583)

2, 15—*C.* (*G.*) *purpurissata* Dall. *2*, (×1.3), *15*, (×1). Hypotype C.A.S. no. 7790, C.A.S. loc. 27569. Recent, West Coast of Mexico, latitude 15° 40′ N. (p. 584)

3, 4—*C.* (*Chione*) *cancellata* (Linnaeus) (×0.85). *3, 4, 8*, hypotype no. 36101; from loc. 6113. Recent, West Indies. (p. 580)

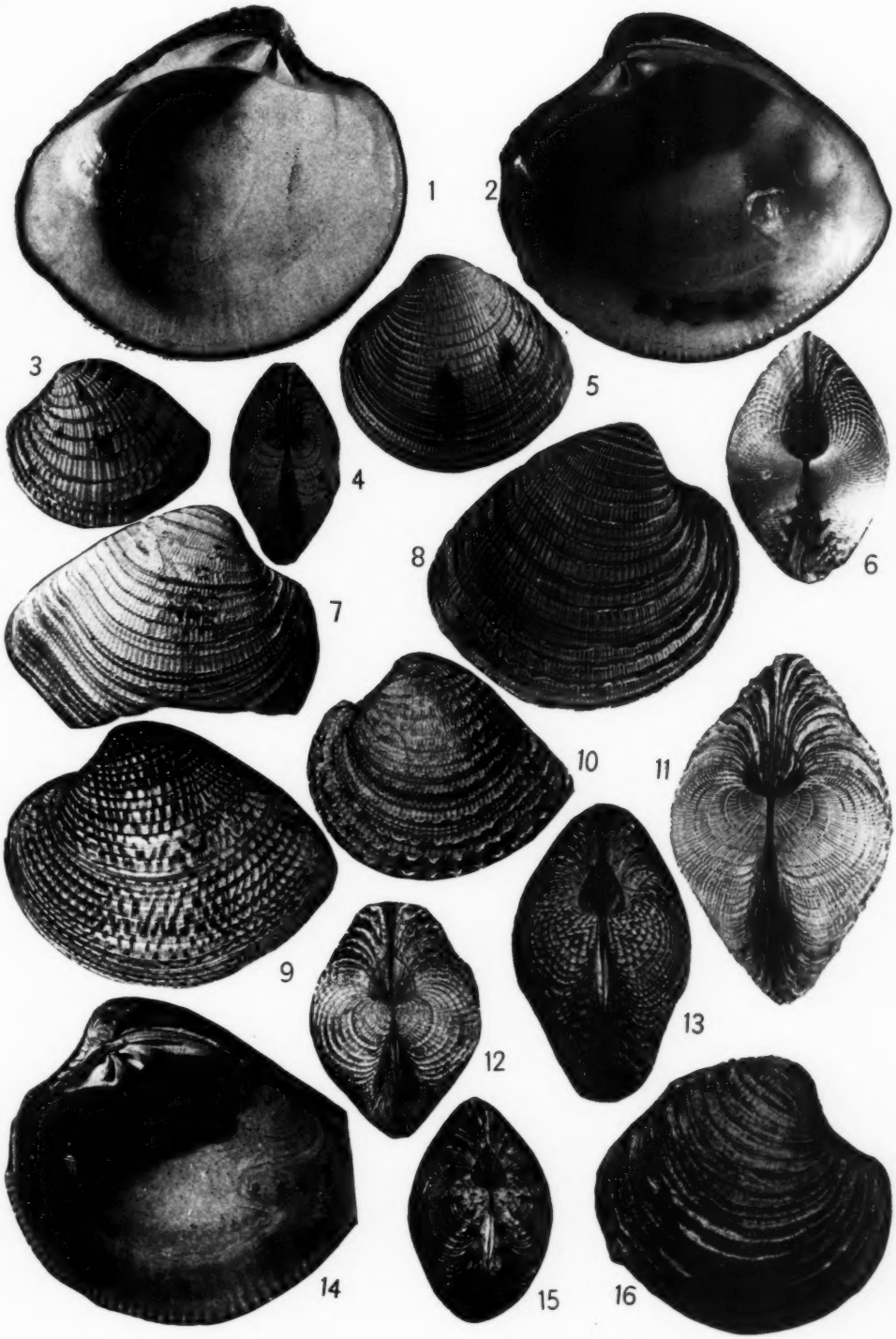
5, 6—*C.* (*C.*) *metadon* Pilsbry and Lowe (×0.66). Hypotype C.A.S. no. 7788. Recent, West Coast of Mexico. (p. 581)

7—*C.* (*Gnidiella*) *temblorensis* (Anderson) (×1). Hypotype no. 36084, loc. 3890. Miocene, Temblor formation of Kern River, California. (p. 584)

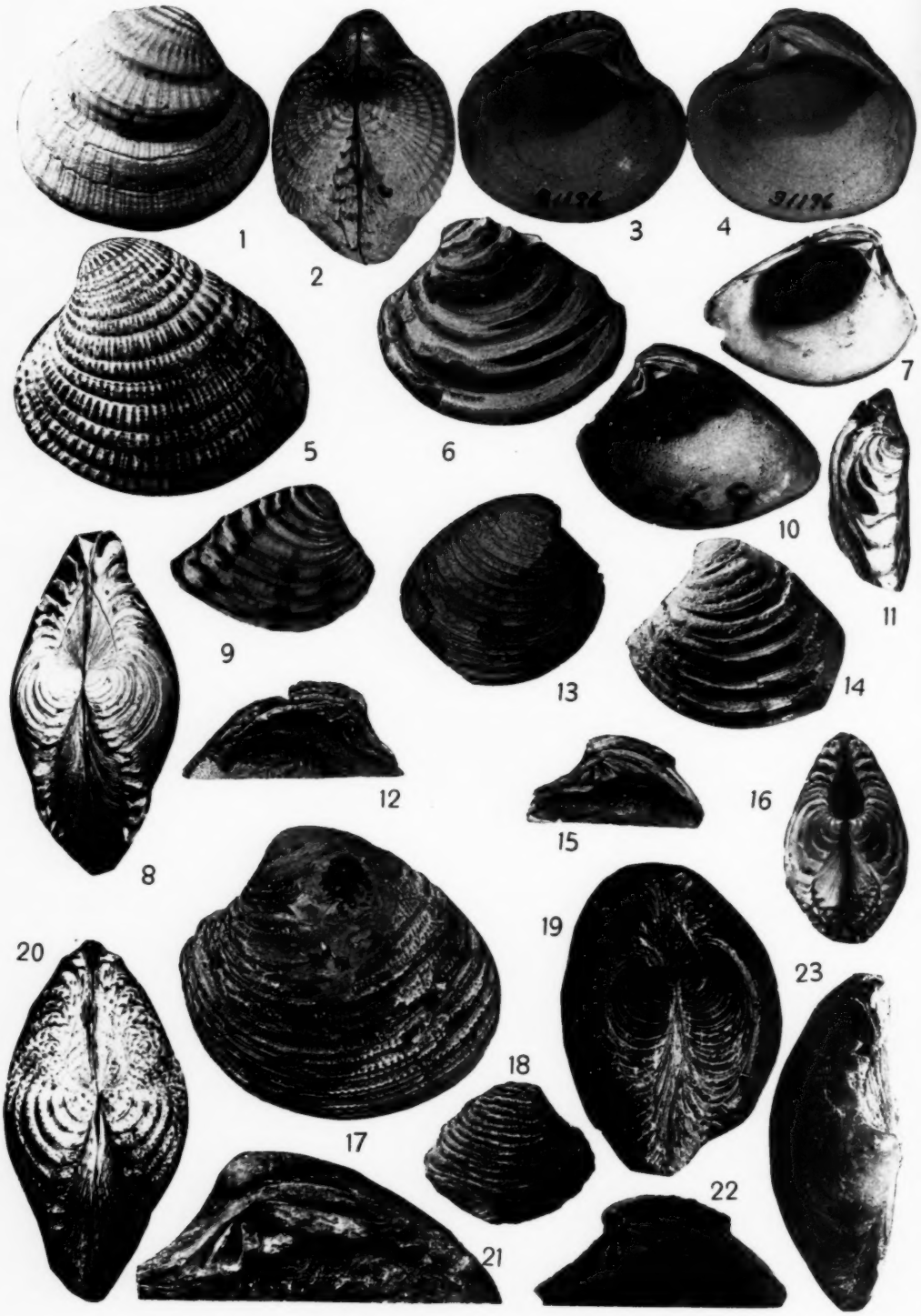
9, 13—*C.* (*G.*) *pulicaria* (Broderip) (×0.85). Hypotype C.A.S. no. 5986, C.A.S. loc. 28186. Recent, Kino Bay, Gulf of California. (p. 583)

10, 12, 14—*C.* (*G.*) *amathusia* (Philippi). *10*, (×0.85) hypotype no. 36081; *12*, (×0.85) hypotype no. 36081; *14*, (×1.3) hypotype no. 36082, all from loc. 2404. Recent, Gulf of California. (p. 582)

16—*C.* (*G.*) *richthofeni* Hertlein and Jordan (×0.85). After Hertlein and Jordan, Proc. C.A.S., 4th series, vol. 16, no. 19, plate 17, fig. 7. Holotype Stanford Univ. Paleo. Type Coll. no. 5143, loc. L.S.J.U. no. 66. Lower Miocene, Isidro formation. San Ignacio, Lower California. (p. 584)



Parker, Fossil and Recent Pelecypoda



Parker, Fossil and Recent Pelecypoda

Dimensions of hypotype.—No. 36081, length 42 mm., height 36 mm., thickness (both valves) 29 mm.

Hypotypes.—Nos. 36081, 36082, loc. 2404, Gulf of California, Recent.

Distribution.—Recent, Gulf of California to Panama.

CHIONE (GNIDIELLA) GNIDIA (Broderip and Sowerby)

Plate 89, figure 12; plate 91, figures 1, 8, 11

Venus gnidia BRODERIP and SOWERBY, 1829, Zool. Jour. vol. 4, p. 364; Sowerby, 1834, Thes. Conch. vol. 2, pl. 154, fig. 25.
Chione gnidia, STEARNS, 1894, Proc. U. S. Nat. Mus. vol. 17, p. 153.
Venus (*Chione*) *gnidia*, GRANT and GALE, 1931, Mem. San Diego Soc. Hist. vol. 1, p. 318, pl. 16, fig. 5.

Hinge typical of subgenus.

Dimensions of hypotype.—No. 36083, length 79 mm., height 69 mm., thickness (both valves) 46 mm., maximum length 105 mm., height 100 mm.

Hypotype.—No. 36083, loc. 2416, Panama. Recent.

Distribution.—Recent, Cedros Island, Lower California, to Peru; Pleistocene, Palos Verdes sands (upper San Pedro series) of San Pedro, California, and intermediate localities to San Ignacio Lagoon, Lower California.

CHIONE (GNIDIELLA) PULICARIA (Broderip)

Plate 91, figures 9, 13; plate 93, figure 7

Venus pulicaria BRODERIP, 1835, Proc. Zool. Soc. London, p. 44.
Venus cingulata SOWERBY, 1855, Thes. Conch. vol. 2, *Venus* 78, fig. 191; not LAMARCK, 1818, *fide* DALL, 1902, Proc. U. S. Nat. Mus. vol. 26, p. 393.
Chione (*Chione*) *pulicaria*, DALL, 1902, Proc. U. S. Nat. Mus. vol. 26, p. 393.

Right middle cardinal very thin; in left valve middle cardinal with anterior side of groove higher than posterior, a condition not found in most other members of the genus; concentric ribs recurve umbonally on anterior third of shell, flattened in middle third, and flared ventrally on posterior third; pallial sinus very deep for *Chione*.

Dimensions of hypotype.—Length 55 mm., height 45 mm.

Hypotype.—C. A. S. Paleo. Type Coll. no. 5986, loc. C. A. S. 28186, Kino Bay, Gulf of California. Recent.

Distribution.—Recent, Gulf of California to Colombia.

EXPLANATION OF PLATE 92

FIGS. *1–4—Chione* (*Anomalocardia*) *tumens* Verrill. *1, 2*, (×1.1); *3, 4*, (×1). Hypotype C.A.S. no. 7789. C.A.S. loc. 31198. Recent, San Marcos Island, Gulf of California. (p. 587)

5—C. (*A.*) *subimbricata* (Sowerby) (×1). Hypotype no. 36088, loc. 5049. Recent, Salinas, Ecuador. (p. 587)

6, 11—C. (*A.*) *latilaminosa* Anderson and Martin (×2). Hypotype no. 33063, loc. 2713. Miocene, Temblor formation of Kern River, California. (p. 586)

7, 9, 10, 16—C. (*A.*) *mariae* (d'Orbigny) (×1). *7, 16*, hypotype C.A.S. no. 7352; *9, 10*, hypotype no. 7353, both from loc. 27569. Recent, West Coast of Mexico, latitude 15° 40′ N. (p. 586)

8—C. (*Anomalocardia*) *kellettii* (Hinds) (×1.4). Hypotype C.A.S. no. 7787, C.A.S. loc. 27580. Recent, West Coast of Mexico, ½ mile east of Isabel Island. (p. 586)

12, 13, 15, 19, 22—Securella clallamensis (Reagan). *12*, (×1), hypotype C.A.S. no. 5984a; *13*, (×0.7), hypotype C.A.S. no. 5984c; *15*, (×1), hypotype C.A.S. no. 5984b, all from C.A.S. loc. 39, Miocene, Astoria formation, Newport, Oregon; *19*, (×1), hypotype C.A.S. no. 5921, C.A.S. loc. 585, Miocene, Clallam formation, 4 miles southeast of east Clallam, Washington. (p. 589)

14—Chione (*Anomalocardia*) *hannai* Bramkamp (×1.7). Holotype no. 36087, loc. A 1407. Miocene. Imperial formation of Imperial Valley, California. (p. 585)

17, 21, 23—C. (*Gnidiella*) *semiplicata* Nomland (×0.6). *17, 23*, holotype no. 11318, loc. 2283; *21*, paratype no. 12071, loc. 2276. Miocene, Santa Margarita formation north of Coalinga, California. (p. 584)

18—C. (*G.*) aff. *richthofeni* Hertlein and Jordan (×1). After Loel and Corey, Univ. Calif. Publ., Bull. Dept. Geol. Sci,. vol. 22, pl. 42, fig. 4. Hypotype no. 31806, loc. A599. Lower Miocene, Purisima Nueva, Lower California. (p. 584)

20—C. (*Anomalocardia*) *subrugosa* (Sowerby) (×1.4). Hypotype no. 36089, loc. 2404. Recent, Gulf of California. (p. 587)

CHIONE (GNIDIELLA) PURPURISSATA Dall
Plate 91, figures 2, 15; plate 93, figure 13

Venus crenulata var. REEVE, 1864, Conch. Icon. vol. 14, fig. 46.
Chione purpurissata DALL, 1902, Proc. U. S. Nat. Mus. vol. 26, p. 393.
Chione montezuma LOWE, 1931, Proc. Acad. Nat. Sci., Phila., vol. 84, p. 101.

Very close to *C.* (*G.*) *pulicaria;* hinge identical, but outline more rounded; concentric ridges very fine and close together.

Dimensions.—(Maximum) length 65 mm., height 57 mm.

Hypotype.—C. A. S. Paleo. Type Coll. no. 7790, loc. C. A. S. 27569, West Coast of Mexico, latitude 15°40′ N. Recent.

Distribution.—Recent, Gulf of California.

CHIONE (GNIDIELLA) RICHTHOFENI
Hertlein and Jordan
Plate 91, figure 16

Chione richthofeni HERTLEIN and JORDAN, 1927, Proc. Calif. Acad. Sci., 4th series, vol. 16, p. 619, pl. 17, figs. 4, 7, 8.

The additional ridges on nymph plate referred to in original description are remnants of the ligament; hinge similar to that of *C. gnidia;* radial ribbing finer and concentric ribs more numerous.

Dimensions of holotype.—Length 50 mm., height 47 mm., thickness (both valves) 31.5 mm.

Holotype.—L. S. J. U. Type Coll. no. 5143, loc. L. S. J. U. no. 66, San Ignacio, Lower California. Isidio formation, lower Miocene.

Paratype.—C. A. S. Paleo. Type Coll. no. 2657, 2658, from same locality.

Distribution.—Lower Miocene, Isidro formation of San Ignacio area, Lower California.

CHIONE (GNIDIELLA) aff. RICHTHOFENI
Hertlein and Jordan
Plate 92, figure 18

Chione aff. *richthofeni* (HERTLEIN and JORDAN), n. sp. LOEL and COREY, 1932, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 22, p. 224, pl. 42, fig. 4.

The type, the only available specimen, is too poorly preserved to permit any detailed comparisons.

Dimensions of hypotype.—Length 26 mm., height 21 mm.

Hypotype.—No. 31806, loc. A 599a, Miocene, Purisima Nueva, Lower California.

Distribution.—Miocene, Vaqueros formation of the San Joaquin Hills, the Channel Islands of California and Miocene of Purisima Nueva, Lower California.

CHIONE (GNIDIELLA) SEMIPLICATA
Nomland
Plate 92, figures 17, 21, 23; plate 93, figure 5

Chione semiplicata NOMLAND, 1917, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 10, pp. 305-306, pl. 15, figs. 2a, 2b, 2c.
Chione vickeryi WIEDEY, 1929, Jour. Paleontology, vol. 3, p. 286, pl. 32, fig. 4.
Venus (*Chione*) *securis* SHUMARD var. *semiplicata,* GRANT and GALE, 1931, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 321.
Chione schencki LOEL and COREY, 1932, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 22, p. 224, pl. 42, fig. 5.

Closely resembling *C. temblorensis* except for absence of any depression on posterior part of shell, resulting in a more rounded outline.

Chione vickeryi is presumably a deformed specimen of *C. semiplicata.* It is reported from the upper Miocene of Alum Rock Canyon, east of San Jose, California. The type of *C. schencki* actually bears the same locality number and has the same matrix as Wiedey's type, but does not have the matrix of locality A 606 from which it was reported by Loel and Corey. It is obviously not a Vaqueros species.

Dimensions of holotype.—Length 80 mm., height 70 mm.

Holotype.—*C. semiplicata* Nomland, no. 11318, loc. 2283, nine miles N.E. of Coalinga; *C. vickeryi* Wiedey, L. S. J. U. no. 518; of *C. schencki* Loel and Corey, L. S. J. U. no. 616. The last two specimens are from L. S. J. U. loc. C-202, Alum Rock Falls, San Jose, California.

Paratype.—*C. semiplicata* Nomland, no 12071, loc. 2276.

Distribution.—Miocene, Santa Margarita formation.

CHIONE (GNIDIELLA) TEMBLORENSIS
(Anderson)
Plate 91, figure 7; plate 93, figure 9

Venus (*Chione*) *temblorensis* ANDERSON, 1905, Proc. Cal. Acad. Sci., 3rd series, vol. 2, p. 196, pl. 14, figs. 36–38; ARNOLD, 1907: Proc. U. S. Nat. Mus., vol. 32, p. 542, pl. 43, fig. 1, 1-a;

ARNOLD, 1907, U.S. Geol. Surv. Bull. 309; pl. 30, figs. 1, 1-a.

Chione temblorensis, ARNOLD, 1909, U.S. Geol. Surv. Folio 163, pl. 2, fig. 39; ARNOLD, 1910, U.S. Geol. Surv. Bull. 396, p. 122, pl. 8, fig. 7; ARNOLD and ANDERSON, 1910, U.S. Geol. Surv. Bull. 398, pl. 30, fig. 7; MCLAUGHLIN and WARING, 1915, California State Min. Bur. Bull. 69, map folio, fig. 29; Clark, 1929, Strat. Faunal Hor. Coast Ranges of Calif., pl. 25, figs. 1–4; LOEL and COREY, 1932, Univ. Calif. Publ. Dept. Geol. Sci., vol. 22, p. 225, pl. 42, fig. 2, SCHENCK and KEEN, 1940, Calif. Foss., pl. 39, figs. 1, 2.

Chione temblorensis subtemblorensis LOEL and COREY, 1932, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 22, p. 225.

This species is very close to *C. gnidia:* right posterior cardinal more deeply grooved and curve in hinge plate more pronounced; concentric ribs tend to crowd toward margin almost obliterating radial ribbing; most prominent difference a depression or sulcus along posterior side giving a rostrate outline to shell. Loel and Corey have proposed the varietal name *subtemblorensis* for individuals not having the sulcus.

Dimensions.—(Maximum) length 66 mm., height 58 mm.

Hypotype.—No. 36084, loc. 3890, Temblor formation of Kern River, California. Miocene. (One mile east of Barker's Ranch.)

Distribution.—Miocene. Vaqueros-Temblor transition zone and Temblor formation of southern California.

Subgenus ANOMALOCARDIA Schumacher, 1817, *emended*

Anomalocardia SCHUMACHER, 1817, Essai Meth., p. 134, pl. 20, fig. 4.

Cryptogramma MORCH, 1853, Cat. Conch. YOLDI, p. 22.

Anomalocardia DALL, 1902, Proc. U. S. Nat. Mus. vol. 26, p. 359.

Subgenotype: *Venus flexuosa* Linnaeus.

Teeth smooth except for slight grooves on almost vertical slope toward the beak; hinge very close to subgenus *Chione s.s.;* sometimes a slight roughening of very narrow nymph plate; radial ribbing may be present but concentric ribs always predominate; concentric ribs very heavy and strongly recurving, or else surface plications or even folds; posterior dorsal margin usually almost straight. The hinge of *Chione* (*Anomalocardia*) *subrugosa* (Sowerby) (Pl. 89, fig. 10 is characteristic of Pacific Coast members of the subgenus.

CHIONE (ANOMALOCARDIA) FERNANDOENSIS English

Plate 95, figures 7, 8, 13, 14, 16, 18

Chione fernandoensis ENGLISH, 1914, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 8, p. 215, pl. 23, figs. 9, 10; CLARK, 1929, Strat. Faunal Hor. Coast Ranges of Calif., pl. 42, figs. 5, 6.

Venus (*Chione*) *securis* SHUMARD var. *fernandoensis*, GRANT and GALE, 1931, Mem. San Diego Soc. Nat. Hist. vol. 1, p. 321, pl. 17, figs. 4–6.

Closely resembling *C.* (*Anomalocardia*) *mariae;* hinge same except for slightly wider angles between teeth and longer anterior cardinals; pallial sinus same; posterior dorsal slope and anterior end more rounded; concentric ribs thinner, similar to first few of *C.* (*A.*) *mariae* and, as in that species, underlying radial ribbing does not appear on surface except where weathered.

Although the hinge is not exposed on the types of *C.* (*A.*) *fernandoensis* from the lower Pliocene, the external form corresponds exactly to specimens from the lower Pleistocene, Saugus formation, whose hinges were observed.

Dimensions of holotype.—Length 21 mm., height 18 mm., thickness (both valves) 11 mm.

Holotype.—No. 11920, loc. 1735, Elsmere Canyon, California. Fernando formation.

Paratype.—No. 11921, from same locality.

Hypotypes.—San Diego Soc. Nat. Hist. no. 159, loc. 209, lower Pliocene of Elsmere Canyon; nos. 36085, 36086, loc. 7095, bluff on east side of Santa Paula Canyon, 1½ miles north of Santa Paula, Ventura County California, Pleistocene.

Distribution.—Lower Pliocene, lower Fernando formation of Los Angeles County, California. Middle Pliocene, Pico formation of the Transverse Ranges of southern California. Lower Pleistocene, Saugus formation of Ventura County, California.

CHIONE (ANOMALOCARDIA) HANNAI Bramkamp MS.

Plate 92, figure 14

Chione (*Lirophora*) *hannai* BRAMKAMP, 1935, Strat. and Moll. Fauna of the Imperial formation of the San Gorgonio Pass, California. MS. deposited in the Univ. Calif. Library.

Original description.—Shell small, subtrigonal, rounded anteriorly, but very faintly truncate posteriorly. Beaks rather high subacute, anterior

to the middle of the shell. Lunule relatively large, defined by a deeply incised line, slightly if at all impressed. Sculpture consisting of 8–10 (shell height about 10 mm.) heavy, swollen, concentric lamellae which are more or less irregular in size, stopping suddenly anteriorly just before reaching the edge of the lunule, and becoming obsolete on the posterior area, and fading out entirely on the escutcheon. Radial sculpture lacking except for faint grooving of the basal part of the marginal lamellae of one specimen. Occasionally subsidiary concentric lamellae may be intercalated between major ones. Posterior area large, about one-fourth the area of the shell, sharply differentiated by the change in sculpture. Escutcheon defined by a moderately sharp ridge, smooth except for incremental lines. Hinge of right valve with anterior cardinal (3a) very long and slender, middle cardinal (1) slightly oblique to it, heavy, faintly grooved on dorsal surface, and posterior cardinal (3b) moderately heavy, also grooved. Hinge of left valve with subequal anterior pair of cardinals (3a and 2b), the former being curved forward at the base, and the posterior cardinal (4b) fused with the nymph plate, and somewhat roughened. Inner margins finely crenulate.

It is readily distinguished from any other West Coast species by its sculpture. Hinge similar to that of *C.* (*A.*) *subrugosa*.

Dimensions of holotype.—Length 10 mm., height 8 mm.

Holotype.—No. 36087, loc. A 1407 (middle of eastern edge of NW. ¼ of SW. ¼, sec. 36, T. 2 S., R. 3 E., San Jacinto Quad., California), lower Pliocene, Imperial formation.

Distribution.—Lower Pliocene, Imperial formation of Imperial Valley, California.

CHIONE (ANOMALOCARDIA) KEI LETTII (Hinds)

Plate 97, figure 8; plate 93, figures 1, 2

Venus kellettii HINDS, 1844, Voyage of the Sulphur, Mollusca, p. 65, pl. 19, fig. 5; SOWERBY, 1855, Thes. Conch. vol. 2, p. 721, pl. 155, fig. 64.

Chione (*Lirophora*) *kellettii*, DALL, 1902, Proc. U. S. Nat. Mus. vol. 26, p. 394.

Hinge and outline same as *C.* (*A.*) *subrugosa;* ornamentation on very early part of shell of thick, smooth, flaring concentric ribs; later they become wide and flattened on central portion of shell and flare only at extreme margins.

Dimensions of hypotype.—(C. A. S. Paleo. Type Coll. no. 7787), length 65 mm., height 52 mm.

Hypotype.—C. A. S. Paleo. Type Coll. no. 7787A-B, C. A. S. loc. 27580, one-half mile east of Isabel Island, West Coast of Mexico.

Distribution.—Recent, Cedros Island, Lower California, to Panama.

CHIONE (ANOMALOCARDIA) LATILAMINOSA Anderson and Martin

Plate 92, figures 6, 11

Chione (*Lorophora*) *latilaminosa* ANDERSON and MARTIN, 1914, Proc. Cal. Acad. Sci., ser. 4, vol. 4, p. 59, pl. 1, figs. 2a, 2b, 2c; CLARK, 1929, Strat. Faunal Hor. Coast Ranges Calif., pl. 42, figs. 5, 6.

May be distinguished from *C.* (*A.*) *mariae* by more rounded outline and greatly recurving concentric ribs; hinge similar to that of *C.* (*A.*) *subrugosa*.

Dimensions of hypotype.—No. 33063, length 19 mm., height 16 mm.

Holotype.—C. A. S. Paleo. Type Coll. no. 118, loc. 65 (west bank of small canyon 1¼ miles northeast of Barker's ranch house, Kern County, California), Temblor formation, Miocene.

Paratypes.—C. A. S. Paleo. Type Coll. nos. 119, 120, from same locality.

Hypotype.—No. 33063, loc. 2713, Temblor formation, Kern River, California.

Distribution.—Miocene, Temblor formation of the Kern River area, California.

CHIONE (ANOMALOCARDIA) MARIAE (d'Orbigny)

Plate 92, figures 7, 9, 10, 16

Venus mariae D'ORBIGNY, 1846, Voy. Amer. Merid., Mollusca, p. 563.

Venus cypria SOWERBY, 1853, Thes. Conch., vol. 2, p. 722, pl. 157, fig. 113.

Chione (*Liprohora*) *mariae*, DALL, 1902, Proc. U. S. Nat. Mus. vol. 26, p. 395.

Venus (*Chione*) *mariae*, GRANT and GALE, 1931, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 324.

The hinge is so small that it shows up poorly in the illustration, but it is essentially like that of *C.* (*A.*) *subrugosa*, as are also those of *C.* (*A.*) *hannai* and *C.* (*A.*) *latilaminosa*.

Dimensions of hypotype.—(C. A. S. Paleo. Type Coll. no. 7352), length 32 mm., height 25 mm.

Hypotypes.—C. A. S. Paleo. Type Coll. nos. 7352, 7353, 7353a, C. A. S. loc. 27569 (latitude 15°40′ N., West Coast of Mexico), Recent.

Distribution.—Recent, Gulf of California to Ecuador. Pleistocene, Magdalena Bay, Lower California.

CHIONE (ANOMALOCARDIA) SUBIMBRICATA (Sowerby)
Plate 92, figure 5

Venus subimbricata SOWERBY (in part), 1835, Proc. Zool. Soc. London, p. 21; 1855, Thes. Conch. vol. 2, figs. 35–37.
Anomalocardia subimbricata, DALL, 1902, Proc. U. S. Nat. Mus., vol. 26, p. 396.

Sculpture of flat, imbricating concentric ribs with superimposed radial ribs; radial ribs increase in number at an early stage by intercalation and splitting. In *C.* (*A.*) *tumens* this tendency starts at much later stage.

Dimensions of hypotype.—No. 36088, length 41 mm., height 37 mm.

Hypotype.—No. 36088, loc. 5049, Salinas, Ecuador. Recent.

Distribution.—Recent, Gulf of California to Ecuador.

CHIONE (ANOMALOCARDIA) SUBRUGOSA (Sowerby)
Plate 89, figure 10; plate 92, figure 20; plate 93, figure 4; plate 94, figure 15

Venus subrugosa SOWERBY, 1834, Genera of Shells, *Venus*, fig. 2; 1855, Thes. Conch. vol. 2, p. 721, pl. 155, fig. 63.
Anomalocardia subrugosa, DALL, 1902, Proc. U. S. Nat. Mus., vol. 26, p. 396.

The sulcus close to posterior margin distinguishes this species from all others of this subgenus; the concentric folds tend to coalesce on some specimens.

Dimensions of hypotype.—No. 36089, length 43 mm., height 33 mm.

Hypotype.—No. 36089, loc. 2404, Gulf of California. Recent.

Distribution.—Recent, Gulf of California to Peru.

CHIONE (ANOMALOCARDIA) TUMENS Verrill
Plate 92, figures 1–4

Venus subimbricata SOWERBY (in part), 1835, Proc. Zool. Soc. London, p. 21; 1855, Thes. Conch. vol. 2, p. 711, pl. 154, fig. 38.
Chione tumens VERRILL, 1870, Amer. Jour. Sci. and Arts, vol. 49, p. 222.
Anomalocardia subimbricata, DALL, 1902 (in part), Proc. U. S. Nat. Mus. vol. 26, p. 396.

Closely related to *C.* (*A.*) *subimbricata;* hinge is same but body outline rounder; shell consists of broad concentric "ridges" each becoming larger than the preceding one; the last two "ridges" together equal about half total shell; "ridges" readily noted on inside of shell.

Dimensions.—(Maximum) length 40 mm., height 35 mm.

Hypotype.—C. A. S. Paleo. Type Coll. no. 7789, loc. C. A. S. no. 31197 (San Marcos Island, Gulf of California), Recent.

Distribution.—Recent, Gulf of California to Panama.

Genus SECURELLA Parker, new genus

Genotype.—*Venus securis* Shumard (Pl. 94, figs. 8, 12, 19; pl. 95, fig. 6).

Ligament deeply sunken in shell, wedging out between hinge plates; right, middle and posterior cardinals slightly grooved; left middle cardinal deeply grooved so that posterior portion of tooth larger and higher than anterior; sculpture of evenly spaced thin concentric ridges arising from a layer of concentrically disposed shelly material; this layer underlain by distinct radial ribs not visible on surface; this condition of exclusively concentric ribs usually modified by erosion of shell, so that the common worn and leached specimens exhibit ornamentation with varying degrees of prominence and numbers of radial and concentric ribs; lunule deeply impressed, it is never removed, but escutcheon is often obliterated at an early stage by erosion. For hinge characters, see also *S. ensifera* (Dall) (Pl. 89, fig. 4).

Securella: from *securis*, the specific name of the genotype.

SECURELLA ALASKENSIS (Clark)
Plate 95, figure 1

Chione securis subsp. *alaskensis* CLARK, 1932, Geol. Soc. America, Bull.; vol. 43, p. 815, pl. 18, figs. 2, 3.
Chione sp. DURHAM, 1944, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 27, p. 146.

This form was described by Clark as a subspecies of *S. securis*, however, it differs from that species in the more pouting lunule and in having finer and more numerous radial ribs. Unfortunately there are no specimens available for an examination of the hinge.

Dimensions of holotype.—Length 35 mm., height 31 mm., thickness (both valves) 17 mm.

Holotype.—No. 30406 (loc. 3868, Poul

Creek formation, Alaska); hypotype no. 35204 (loc. A 3692, basal Clallam formation, Washington).

Distribution.—Basal Clallam formation (Miocene) of Washington and Poul Creek formation, Alaska (although determined as upper Oligocene by Clark, the fauna at the type locality of this species appears to have more Miocene than Oligocene affinities).

SECURELLA BISCULPTA (Dall)
Plate 94, figures 6, 17

Chione bisculpta DALL, 1909, U. S. Geol. Surv. Prof. Pap. 59, p. 121, pl. 11, figs. 10, 12; HOWE, 1922, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 14, no. 3, check list; WEAVER, 1943, Univ. Wash. Publ. Geol., vol. 5, pp. 168–169, pl. 40, figs. 2, 3.

Figures of the type indicate considerable weathering, so that little can be determined concerning its systematic relationships. A specimen in the California Academy of Sciences collections is too poorly preserved to be of use for comparison.

Dimensions of holotype.—Length 45 mm., height 42 mm.

Holotype.—U. S. Nat. Mus. no. 153941, Empire formation, Coos Bay, Oregon.

Distribution.—Pliocene, Empire formation of Coos Bay, Oregon.

SECURELLA CARMANAHENSIS (Clark)
Plate 95, figures 20, 21

Chione carmanahensis CLARK, 1925, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 15, no. 4, p. 93, pl. 18, figs. 1–4; WEAVER, 1943, Univ. Wash. Publ. Geol., vol. 5, p. 167, pl. 39, figs. 4, 9, 10; DURHAM, 1944, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 27, p. 146.

The specimens are too poorly preserved to permit detailed comparisons with other forms. Better material may prove it to be a synonym of *S. clallamensis*.

Dimensions of holotype.—Length 35 mm., height 31 mm.

Holotype.—C. A. S. Invert. Paleo. Coll. no. 683, C. A. S. loc. 234 (seacliff along beach one mile west of Carmanah Point, Vancouver Island, British Columbia), upper Oligocene.

Paratype.—No. 684 C. A. S. Invert. Paleo. Coll., from same locality.

Distribution.—Upper Oligocene, Sooke formation of Vancouver Island, British Columbia, and upper Twin Rivers formation of Washington.

EXPLANATION OF PLATE 93

FIGS. *1, 2—Chione* (*Anomalocardia*) *kellettii* (Hinds). *1*, (×1.33), hypotype C.A.S. no. 7787A; *2*, (×0.9), hypotype C.A.S. no. 7787B, both from loc. 27580. Recent, West Coast of Mexico, ½ mile east of Isabel Island. (p. 586)

3, 10, 12—Securella ensifera (Dall) (×1.3). *3*, hypotype C.A.S. no. 5978, C.A.S. loc. 913. Miocene, ten miles southeast of Montesano, Washington, *10*, hypotype no. 36097; *12*, hypotype no. 36096, both from loc. A 340. Miocene, Astoria formation, southwestern Washington. Fig. *12* after Etherington, 1931. (p. 590)

4—Chione (*Anomalocardia*) *subrugosa* (Sowerby) (×1.3). Hypotype no. 36089, loc. 2404. Recent, Gulf of California. (p. 587)

5—C. (*Gnidiella*) *semiplicata* Nomland (×0.66). Holotype no. 11318, loc. 2283. Miocene, Santa Margarita formation, north of Coalinga, California. (p. 584)

6—Protothaca fluctifraga (Sowerby) (×1.3). Hypotype no. 36102, loc. 1657. Recent, Mission Bay, California. (p. 593)

7—Chione (*Gnidiella*) *pulicaria* (Broderip) (×1.3). Hypotype C.A.S. no. 5986, C.A.S. loc. 28186. Recent, Kino Bay, Gulf of California. (p. 583)

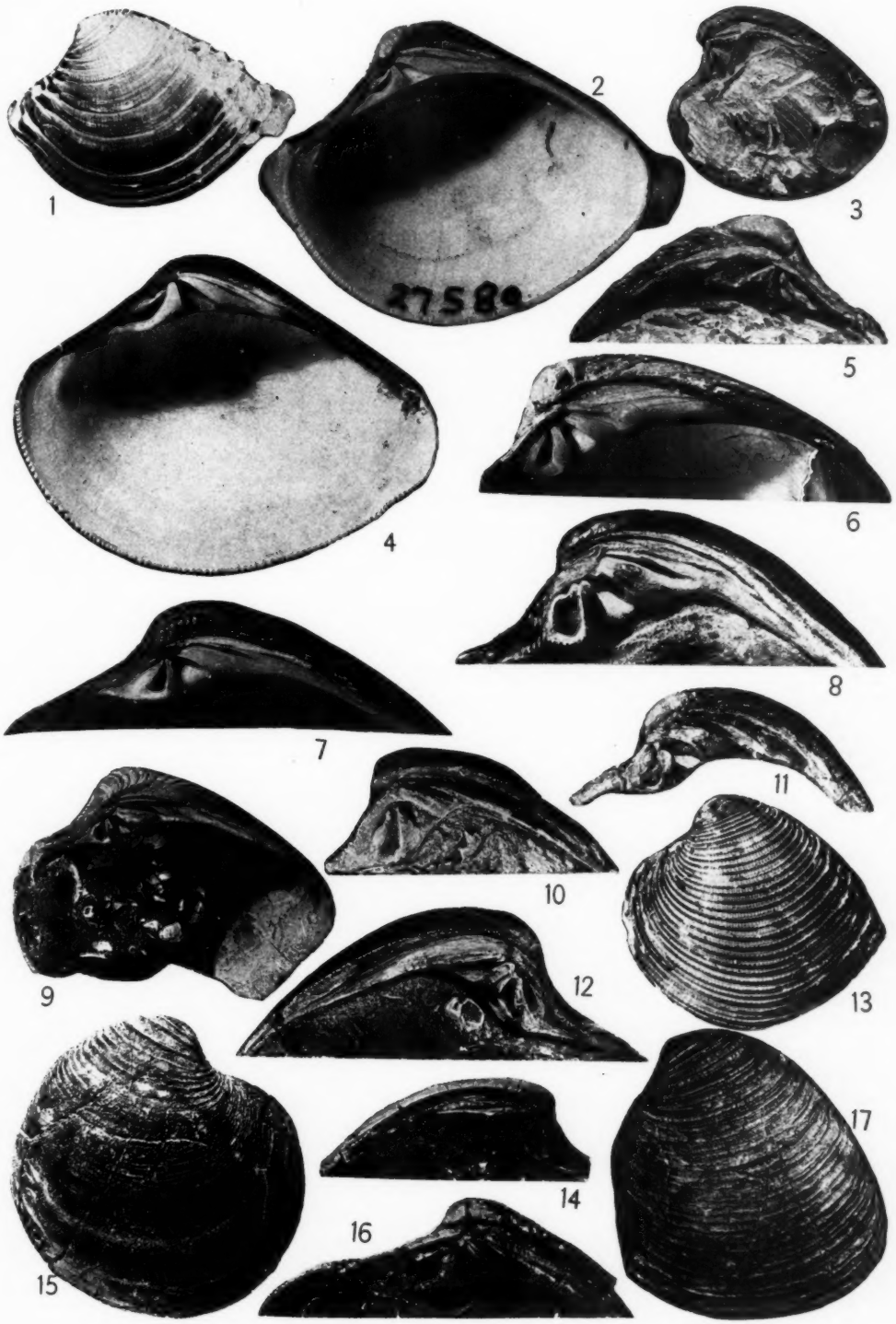
8, 17—Securella cryptolineata (Clark). *8*, (×1.3), hypotype no. 36095; *17*, (×0.85), hypotype no. 36094, both from loc. 1131. Oligocene, San Ramon formation, Walnut Creek, California. (p. 589)

9—Chione (*Gnidiella*) *temblorensis* (Anderson) (×1). Hypotype no. 36084, loc. 3890. Miocene, Temblor formation of Kern River, California. (p. 584)

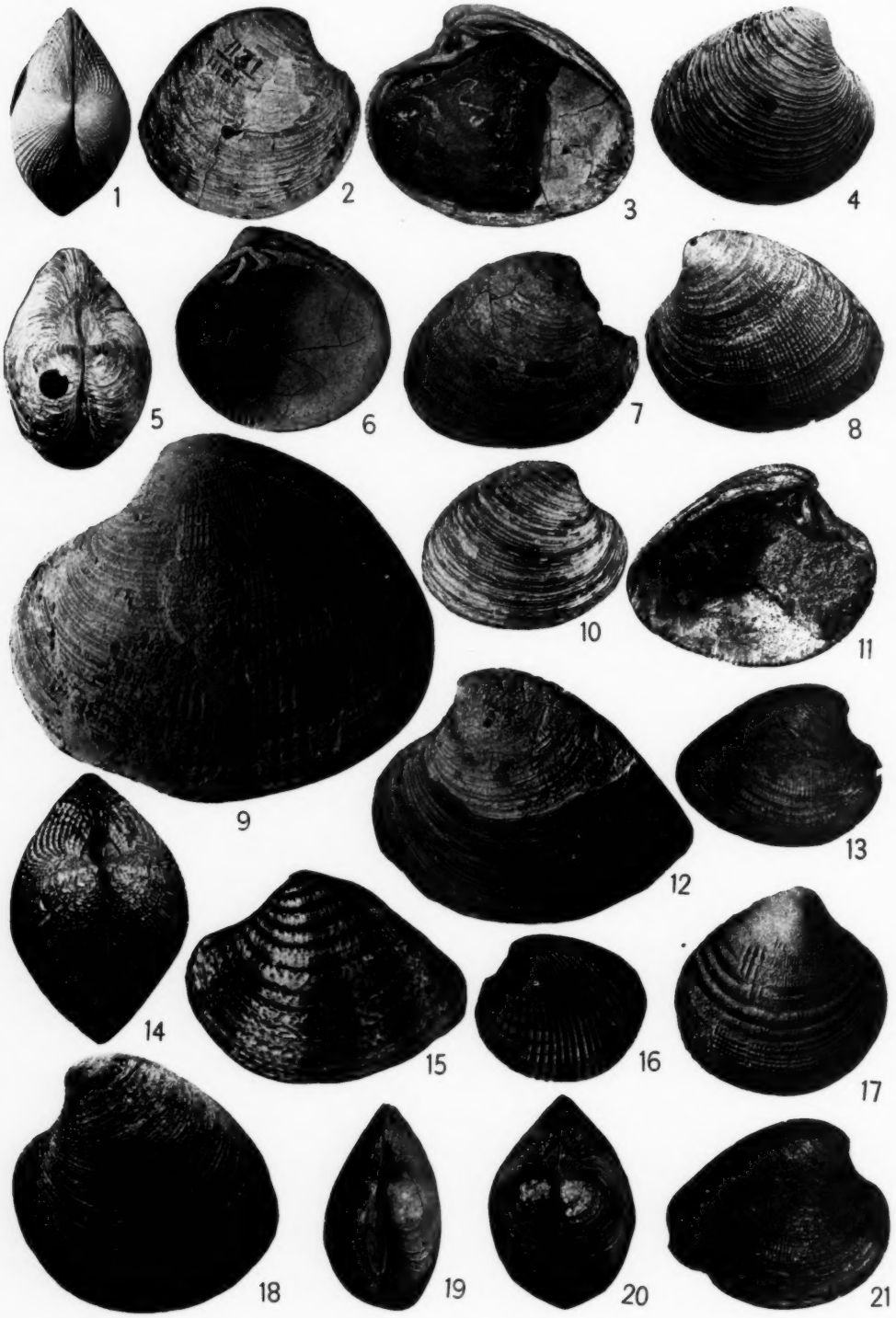
11, 15—Securella juanensis (Loel and Corey) (×0.66). Holotype no. 31803, loc. A 505. Miocene, Temblor formation, California. (p. 591)

13—Chione (*Gnidiella*) *purpurissata* Dall (×1). Hypotype C.A.S. no. 7790, C.A.S. loc. 27569. Recent, West Coast of Mexico, latitude 15° 40′ N. (p. 584)

14, 16—Securella elsmerensis (English) (×0.66). *14*, lectotype SDSNH no. 151; *16*, hypotype SDSNH no. 152, both from SDSNH loc. 202, lower Pliocene of Elsmere Canyon, Los Angeles County, California (after Grant and Gale, 1931). (p. 590)



Parker, Fossil and Recent Pelecypoda



Parker, Fossil and Recent Pelecypoda

SECURELLA CLALLAMENSIS (Reagan)
Plate 92, figures 12, 13, 15, 19, 22

Venus (*Chione?*) *clallamensis* REAGAN, 1909, Kansas Acad. Sci. Trans., vol. 22, p. 183, pl. 1, fig. 13.
Venus (*Chione?*) *securis* SHUMARD var. *ensifera* DALL, GRANT and GALE (in part), 1931, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 320.
Chione clallamensis, DURHAM, 1944, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 27, p. 146.

Very close to *S. cryptolineata*, may be distinguished by the following means: the lunule tending to turn outward at contact of margins: right anterior cardinal more separated from margins, ventral end of right middle cardinal curves anteriorly, resulting in a very narrow groove for left anterior cardinal. These differences are admittedly small and are variable in development; the most apparent difference lies in the somewhat thinner and less inflated shell of *S. clallamensis;* to be separated from *S. securis* by right anterior cardinal partially connected to margin of shell while in that species it is well separated and curved.

Dimensions of hypotype.—C. A. S. no. 5984c, length 45 mm., height 40 mm.

Hypotypes.—C. A. S. Paleo Type Coll. no. 5921 (C. A. S. loc. 585, Clallam formation, 4 miles southeast of East Clallam, Washington), 5984, 5984a, 5984b, 5984c, from C. A. S. loc. 39, Astoria formation, Newport, Oregon. Whereabouts of Reagan's type unknown, apparently not in Kansas Academy of Science collections.

Distribution.—Middle Miocene, Clallam formation of Washington, and Astoria formation of Oregon.

SECURELLA CRYPTOLINEATA (Clark)
Plate 93, figures 8, 17; plate 94, figures 2, 5 10, 11, 13, 21; plate 95, figure 10

Chione cryptolineata CLARK, 1918, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 11, p. 149, pl. 5, figs. 1–4; SCHENCK and KEEN, 1940, Calif. Foss., pl. 3, fig. 2.
Chione lineolata CLARK, *ibid.*, p. 150, pl. 6, figs. 1, 2, 5.
Chione mediostriata CLARK, *ibid.*, p. 150, pl. 5, figs. 5, 6; pl. 6, figs. 3, 4.
Chione mediastriata, CLARK, 1929, Strat. Faunal Hor. Coast Ranges Calif., pl. 16, fig. 7; pl. 17, figs. 1, 2.
?Chione cf. *cryptolineata*, CLARK, 1932, Bull. G.S.A., vol. 43, pp. 815–816.

Some twenty topotype specimens representing Clark's species were prepared and

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EXPLANATION OF PLATE 94

FIG. *1*—*Protothaca fluctifraga* (Sowerby) (×0.3). Hypotype Stanford Univ. Paleo. Type Coll. no. 6957. Recent, Almejos Bay, Lower California. A variety with a flatter and smoother shell. (p. 593)
2—*Securella cryptolineata* (Clark) (×0.5). Holotype (of *Chione mediostriata* Clark) no. 11181, loc. 1131. Oligocene, San Ramon formation, Walnut Creek, California. (p. 589)
3, 7—*Securella panzana* (Anderson and Martin). *3*, (×0.66), hypotype Stanford Univ. Paleo. Type Coll. no. 6954; *7*, (×0.5), hypotype Stanford Univ. Paleo. Type Coll. no. 6955. Miocene, Freeman silt, Bakersfield quadrangle, California. (p. 592)
4, 18, 20—*S. ensifera* (Dall) (×0.66). *4*, hypotype C.A.S. no. 5976, C.A.S. loc. 913. Miocene, ten miles southeast of Montesano, Washington. *18*, hypotype no. 31960, loc. 9008. Miocene, Astoria formation, Washington; *20*, hypotype no. 31959, loc. 9015. Miocene, Astoria formation, Washington. *18* and *20* after Etherington, 1931. (p. 590)
5, 10—*S. cryptolineata* (Clark). *5*, (×0.8); *10*, (×0.5), holotype (of *Chione cryptolineata*) no. 11178 loc. 1131. Oligocene, San Ramon formation, Walnut Creek, California. (p. 589)
6, 17—*S. bisculpta* (Dall) (×0.66). After Dall, U.S.G.S. Prof. Paper 59, pl. 11, figs. 10–11. Holotype U. S. Nat. Mus. no. 153941. Miocene, Coos Bay, Oregon. (p. 588)
8, 12, 19—*S. securis* (Shumard). *8, 19* (×0.45), hypotype no. 31961. Pliocene, Wildcat formation, Humboldt County, California; *12*, (×0.66), hypotype no. 36099, loc. 3321. Pliocene, Empire formation, Coos Bay, Oregon. (p. 593)
9—*S. elsmerensis* (English) (×0.66). Holotype (after English, 1914) from loc. 1735. Pliocene, lower Fernando formation, Elsmere Canyon, Los Angeles County, California. (Specimen since lost.) (p. 590)
11, 13, 21—*S. cryptolineata* (Clark). *11*, (×0.66), hypotype no. 36091; *13*, (×0.5), hypotype no. 36093; *21*, (×0.5), hypotype no. 36090, all from same loc. as fig. 5. (p. 589)
14, 16—*Protothaca columbiensis* (Sowerby). *14*, (×1.33), hypotype no. 36103; *16*, (×0.66), hypotype no. 36104, both from loc. 3092. Recent, Mazatlan, Mexico. (p. 593)
15—*Chione* (*Anomalocardia*) *subrugosa* (Sowerby) (×0.9). Hypotype no. 36089, loc. 2404. Recent, Gulf of California. (p. 587)

examined. All three "species" were found in association, and the differences noted were found to be due to various degrees of weathering plus individual variation.

Within the genus, *S. cryptolineata* has, in proportion to its size, by far the heaviest hinge plate and shell. It shows strong affinities with *S. clallamensis*, and may be a variant of the latter adapted to a different environment, presumably characterized by coarser sediment and rougher water.

Dimensions of hypotype.—No. 36090, length 65 mm., height 55 mm., thickness (one valve) 21 mm.

Holotype.—No. 11178 (*C. cryptolineata*); 11123 (*C. lineolata*); 11181 (*C. mediostriata*).

Paratypes.—Nos. 11179, 11180 (*C. cryptolineata*); 11126 (*C. lineolata*); 11124, 11125, 11182 *C. mediostriata*).

Hypotypes.—Nos. 36090, 36091, 36092, 30693, 36094, 36095. All types from loc. 1131 (½ mile southwest of Walnut Creek, Contra Costa County, California; in creek bed about 100 yards east of railroad bridge), San Ramon formation, upper Oligocene.

Distribution.—San Ramon formation, upper Oligocene of Mt. Diablo region, California; ?Poul Creek formation, upper Oligocene, Alaska.

SECURELLA ELSMERENSIS (English)

Plate 93, figures 14, 16; plate 94, figure 9

Chione elsmerensis ENGLISH, 1914, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 8, p. 214, pl. 23, fig. 1; NOMLAND, 1916, Univ. Calif, Publ., Bull. Dept. Geol. Sci., vol. 9, pp. 202, 210, pl. 9, figs. 3a, 3b; pl. 10, fig. 1; CLARK. 1929, Strat. Faunal. Hor. Coast Ranges Calif., pl. 43, fig. 1.

Venus (*Chione*) *elsmerensis*, GRANT and GALE, 1931, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 319, pl. 16, figs. 6, 7.

Hinge typical of genus except for larger angle between middle and posterior cardinals; beaks less produced and more centrally located than in any other member of *Securella;* very close to *S. panzana* but may be distinguished by more centrally located beaks and fewer and larger radial ribs.

Dimensions.—Length 95 mm., height 85 mm. (estimated).

Type.—As the holotype is lost, the following lectotype has been chosen: San Diego Soc. Nat. Hist. no. 151, loc. 202, lower Pliocene of Elsmere Canyon, California. Hypotypes San Diego Soc. Nat. Hist., no. 152, same locality; no 33055, loc. 2655, Jacalitos formation, Coalinga Quad., California.

Distribution.—Lower Pliocene of Elsmere Canyon, Los Angeles County, in the lower Fernando formation, and in the Jacalitos formation of the San Joaquin Valley.

SECURELLA ENSIFERA (Dall)

Plate 95, figure 4; plate 93, figures 3, 10, 12; Plate 94, figures 4, 18, 20

Venus lamellifera CONRAD, 1849, Geol. U. S. Expl. Exp., p. 724, pl. 17, fig. 12; not CONRAD, 1837, Jour. Acad. Nat. Sci., Phila., vol. 7, p. 251, pl. 19, fig. 19.

Venus ensifera DALL, 1909, U. S. Geol. Surv., Prof. Pap. 59, p. 122.

Chione chehalisensis WEAVER, 1912, Wash. State Geol. Surv., Bull. 15, p. 60, pl. 8, fig. 71.

Chione (*Chione*) *ensifera*, ETHERINGTON, 1931, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 20, no. 5, p. 79, pl. 7, figs. 4–8; pl. 8, figs. 1, 2; pl. 9, figs. 4, 5, 8, 11.

Venus (*Chione*) *securis* SHUMARD var. *ensifera*, GRANT and GALE, 1931, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 320, p. 17, figs. 2, 3.

Chione ensifera var. *chehalisensis* WEAVER, 1943, Univ. Wash. Publ. Geol., vol. V, pp. 165–166, pl. 37, fig. 2; pl. 39, fig. 1.

?Venus (*Chione*) *securis*, SLODKEWITSCH, 1938, Pal. U.S.S.R. ,vol. 10, pt. 3, fasc. 19, pt. II, pp. 162–163, pl. 87, figs. 3, 4a, 4b.

Very closely related to *S. securis* (which see for comparison); also quite similar to *S. cryptolineata*, but may be easily separated as follows: right middle cardinal smooth, in *S. cryptolineata* grooved; right anterior cardinal separated from margin and convexly curved toward the anterior of shell; hinge plate as a whole smaller and more delicate. The relations of *S. ensifera* to *S. clallamensis* are more difficult to interpret: all specimens of *S. clallamensis* smaller than smallest specimen of *S. ensifera* so that some of the differences may be due to age; shell of *S. clallamensis* more delicate; hinge plate intermediate between *S. ensifera* and *S. cryptolineata*, the right anterior cardinal being further separated from the margin than in *S. cryptolineata* but not curved as in *S. ensifera;* lunule of *S. ensifera* more deeply impressed and lunular areas of valves together form a flat surface, thus not visible from an external side view.

To quote from Etherington, "There is one variety of this species described by Dr. Weaver

as *Chione chehalisensis* from the Montesano beds, which composes the upper portion of the Clemons section," and "A complete series from the Astoria beds shows a gradation from *C. ensifera* Dall to *C. chehalisensis* Weaver, and for that reason the latter is reduced to the variety. The typical *C. ensifera* Dall does not occur beyond the middle Miocene but this rounder, thicker variety lived on into lower Montesano time, *C. ensifera* Dall being replaced by a species related to *C. securis* which is so common in the Pliocene deposits of the coast. *C. ensifera chehalisensis* is not known from deposits younger than lower Montesano."

Dimensions of hypotype.—No. 36096, length 55 mm., height 51 mm., thickness (1 valve) 17 mm.; maximum size, length 75 mm., height 68 mm.

Types.—Holotype of *Venus lamellifera* Conrad, U. S. Nat. Mus. no. 3611, Astoria formation, Miocene, Astoria, Oregon.

Hypotypes nos. 31956 ("topotype"); 31957, 31958 (loc. 9008, Clemons Logging Railroad, SE. ¼ of SW. ¼, sec. 23, T. 17 N., R. 7 W., Grays Harbor County, Washington, Astoria formation, Miocene); 31959 (loc. 9015, one-half mile north of loc. 9008); 36096, 36097, (loc. A 340, along railroad three-fourths mile SE. of loc. 9008, Astoria formation, Miocene). Of *C. ensifera* var. *chehalisensis* Weaver (holotype lost) hypotypes nos. 31960, 31964, 31965 (loc. 9008); 31965 (loc. 9019, railroad cut along south bank of Chehalis River, center of NE. ¼, sec. 13, T. 17 N., R. 7 W., Grays Harbor County, Washington. Astoria formation, Miocene).

Distribution.—In the Astoria and lower Montesano formations, middle and upper Miocene of Washington and Oregon. Slodkewitsch gives a clear figure of "*Venus securis* Shumard," more probably *Securella ensifera* var. *chehalisensis*, from the sea coast between the Amanina and Etalonnaya Rivers on the west coast of Kamchatka, Siberia.

SECURELLA JUANENSIS (Loel and Corey)
Plate 93, figures 11, 15

Chione juanensis LOEL and COREY, 1932, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 22, p. 223, pl. 42, figs. 1a, 1b.

The available specimens are all deformed as well as eroded. Insofar as can be told it most closely resembles *S. cryptolineata* in outline and hinge as well as the general heaviness of the shell.

Dimensions of holotype.—Length 69 mm., height 68 mm.

Holotype.—No. 31803, paratypes no. 31804, and C. A. S. Paleo. Type Coll. no. 6786, all from loc. A 505, just east of middle point of west line of sec. 7, T. 30 S., R. 18 E., La Panza Quadrangle, California, fossiliferous zone at top of white sandstone bed, Vaqueros-Temblor transition beds, Miocene.

Distribution.—Miocene, Vaqueros-Temblor transition zone of La Panza Mountains, California.

SECURELLA MONTESANOENSIS (Weaver)
Plate 25, figures 2, 4, 12, 17, 19

Chione montesanoensis WEAVER, 1912, Bull. Wash. Geol. Surv. no. 15, p. 61, pl. 12, figs. 95, 97, 103; WEAVER, 1943, Univ. Wash. Publ. Geol., vol. 5, pp. 166–167, pl. 38, fig. 11.

Hinge with an unusually long left anterior cardinal and right middle cardinal; neither sculpture nor outline typical of *Securella* although the hinge fits the general formula. When larger specimens of *S. montesanoensis*, and better specimens of *S. bisculpta* are found, they may prove to be synonymous.

Dimensions.—Length 29 mm., height 27 mm.

Paratype.—C. A. S. Paleo. Type Coll. no. 503.

Hypotypes.—C. A. S. Paleo. Type Coll. nos. 7784, 7785, 7786, all from C. A. S. loc. 200, Sylvia Creek, 6 miles north of Montesano, Washington. In conglomerate, Montesano formation, upper Miocene.

Distribution.—Lower Montesano formation of Washington, upper Miocene.

SECURELLA (?) OLYMPIDEA (Reagan)

Venus (*Chione?*) *olympidea* REAGAN, 1909, Trans. Kansas Acad. Sci., vol. 22, p. 182, pl. 1, fig. 12.
Antigona olympidea, DALL, 1922, Am. Jour. Sci., ser. 5, vol. 4, p. 307.
Venus (*Chione?*) *olympidae*, GRANT and GALE, 1931, Mem. San Diego Soc. Nat.. Hist, vol. 1, p. 321.
"*Venus* (*Chione?*) *olympidea*," WEAVER, 1943, Univ. Wash. Publ. Geol., vol. 5, p. 169, pl. 39, fig. 14.

Reagan's type of this species has been well figured by Weaver. However, until topotype material is collected, the species cannot be adequately described or recognized. The type is an internal cast showing

the pallial sinus which appears to indicate that it is referable to *Securella*.

Holotype.—U. S. Nat. Mus. no. 328311.

Distribution.—Clallam formation of Washington.

SECURELLA PANZANA (Anderson and Martin)

Plate 94, figures 3, 7; plate 95, figures 3, 5

Chione panzana ANDERSON and MARTIN, 1914, Proc. Cal. Acad. Sci., 4th series, vol. 4, p. 58, pl. 1, figs. 1a, 1b; CLARK, 1929, Strat. Faunal Hor. Coast Ranges Calif., pl. 26, fig. 1.

Chione margaritana ANDERSON and MARTIN, *ibid.*, p. 59, pl. 2, fig. 1.

Chione diabloensis CLARK, 1915, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 8, p. 468, pl. 58, fig. 4.

Chione pabloensis CLARK, *ibid.*, p. 469, pl. 58, figs. 1, 2; 1929, Strat. Faunal Hor. Coast Ranges Calif., pl. 33, fig. 5.

Chione valentinei WIEDEY, 1929, Jour. Paleontology, vol. 3, p. 282–284, pl. 31, fig. 4, pl. 32, fig. 1.

The differences between *S. panzana*, *S. margaritana*, *S. diabloensis*, *S. pabloensis* and *S. valentinei* are more apparent than real. The stated differences are all due to weathering or deformation of the specimens. On the basis of the hinge they are inseparable, and in so far as the preservation of the shell permits comparison, they all have the same type of ornamentation. *S. panzana* is separable from *S. ensifera* by its much longer shell.

Dimensions.—Length 80 mm., height 65 mm.

Holotype.—C. A. S. Paleo. Type Coll. no. 115 (*C. panzana*), C. A. S. loc. 53 (center of SE. ¼, sec. 22, T. 29 S., R. 16 E., San Luis Obispo County, California); C. A. S. Paleo. Type Coll. no 117 (*C. margaritana*), (NE. ¼, sec. 25, T. 21 S., R. 14 E., Coalinga, California), Santa Margarita formation, upper Miocene; no. 12325 (*C. diabloensis*) loc. 1492 (east of Walnut Creek, Contra Costa County, California), upper San Pablo Group, Miocene; no. 12327 (*C. pabloensis*), loc. 1485 (south side of Mount Diablo, California), upper San Pablo group, Miocene; L. S. J. U. Paleo. Type Coll. no. 517 (*C. valentinei*), L. S. J. U. loc. 448 (2 miles south of Mayfield, Santa Clara County, California).

Paratype.—C. A. S. Paleo. Type Coll. no. 116, C. A. S. loc. 53, (see above) L. S. J. U. Paleo. Type Coll. no. 6956 (*C. valentinei*), same locality as holotype.

Hypotypes.—L. S. J. U. Paleo. Type Coll. nos. 6954, 6955, 6956 (Freeman silt, Bakers-

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EXPLANATION OF PLATE 95

FIG. *1*—*Securella alaskensis* (Clark) (×1). Holotype no. 30406, loc. 3368. Oligocene, Alaska (after Clark, 1932). (p. 587)

2, 4, 12, 17, 19—*S. montesanoensis* (Weaver). *2, 12, 19*, (×1); *4, 17*, (×0.75). *2, 17, 19*, hypotype C.A.S. no. 7785; *4*, hypotype C.A.S. no. 7784; *12*, hypotype C.A.S. no. 7786; all from C.A.S. loc. 200. Miocene, Montesano, Washington. (p. 591)

3, 5—*S. panzana* (Anderson and Martin). *3*, (×0.5), hypotype Stanford Univ. Paleo. Type Coll. no. 6954. Miocene, Freeman silt, Bakersfield quadrangle, California. *5*, (×1), hypotype, Stanford Univ. Paleo. Type Coll. no. 6956, loc. L.S.J.U. 448. Miocene, Santa Clara County, California (paratype of *Chione valentinei* Wiedey). (p. 592)

6—*S. securis* (Shumard) (×1). Hypotype no. 36100, loc. A 88. Pliocene, Empire formation, Coos Bay, Oregon. (p. 593)

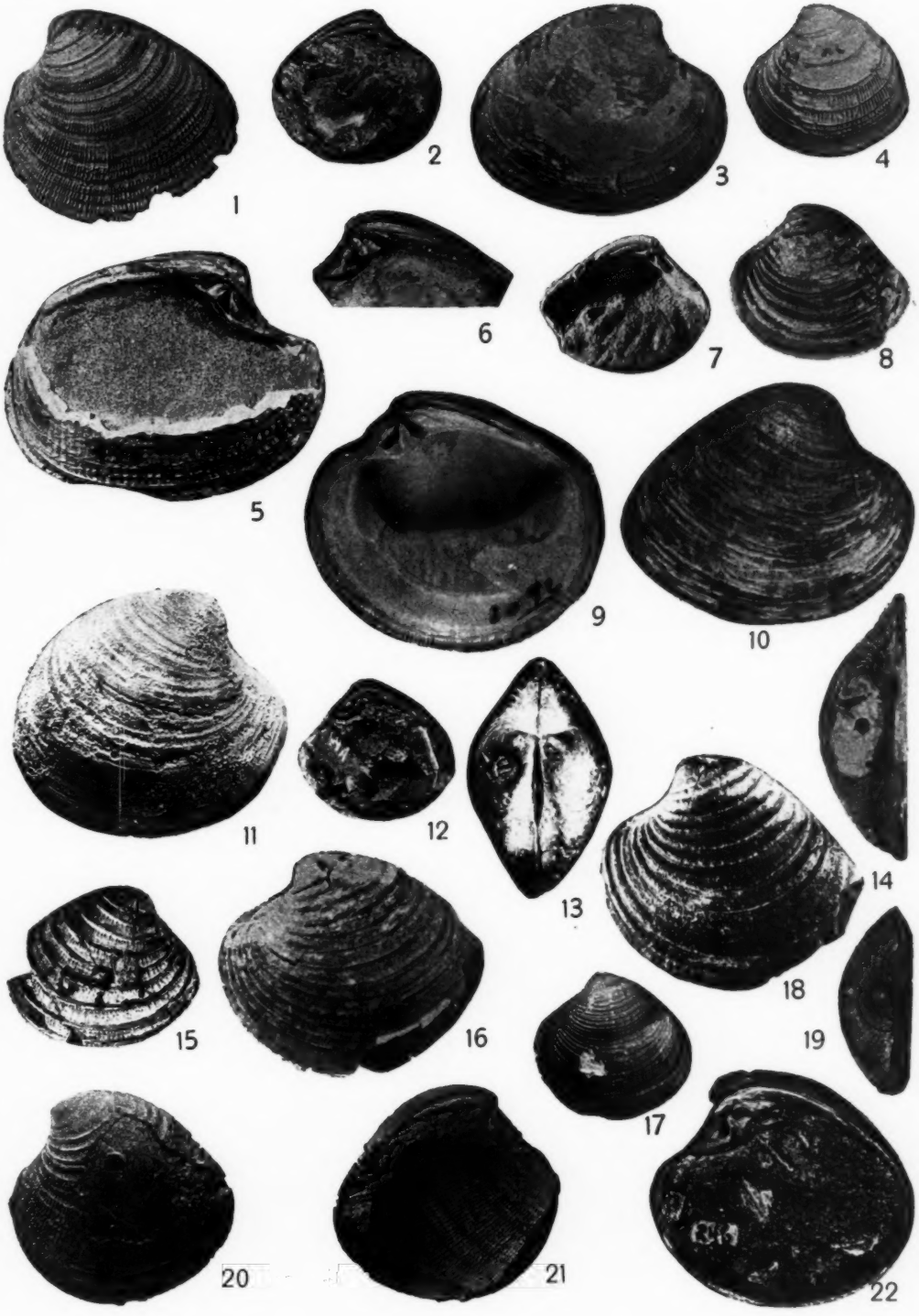
7, 8, 13, 14, 15, 16, 18—*Chione* (*Anomalocardia*) *fernandoensis* English. *7, 13, 15, 18*, (×2); *14, 16*, (×1). *7, 8*, hypotype no. 36086; *15*, hypotype no. 36085, loc. 7095. Pleistocene, Saugus formation of Ventura County, California. *13, 18*, paratype no. 11921, loc. 1735. *14, 16*, hypotype SDSNH no. 159, loc. SDSNH no. 209, Elsmere Canyon, California (after Grant and Gale, 1931). (p. 585)

9—*Protothaca columbiensis* (Sowerby) (×1.3). Hypotype no. 36103, loc. 3092. Recent, Mazatlan, Mexico. (p. 593)

10—*Securella cryptolineata* (Clark) (×0.75). Hypotype no. 36092, loc. 1131. Oligocene, San Ramon formation, Walnut Creek, California. (p. 589)

11, 22—*S. vancouverensis* (Clark and Arnold) (×1). Holotype, Stanford Univ. Paleo. Type Coll. no. 246, loc. N.P. 129. Oligocene, Sooke formation, Vancouver Island, British Columbia (after Clark and Arnold, 1923). (p. 593)

20, 21—*S. carmanahensis* (Clark) (×1). Holotype C.A.S. no. 683, C.A.S. loc. 234. Oligocene, Carmanah Point, Vancouver Island, British Columbia (after Clark, 1925). (p. 588)



Parker, Fossil and Recent Pelecypoda

field area); nos. 33060, 36098, both from loc. A 491 (Stills Ranch, La Panza, California), Temblor formation, Miocene.

Distribution.—Temblor formation, Miocene of Central and Southern California.

SECURELLA SECURIS (Shumard)

Plate 94, figures 8, 12, 19; plate 95, figure 6

Venus securis SHUMARD, 1858, Trans. St. Louis Acad. Sci., vol. 1, p. 122.

Chione securis, DALL, 1909, U. S. Geol. Surv. Prof. Pap. 59, p. 120, pl. 11, fig. 8, pl. 13, figs. 2, 8, 9; ARNOLD, 1910, U. S. Geol. Surv. Bull. 396, p. 136, pl. 15, fig. 2; ARNOLD and ANDERSON, 1910, U. S. Geol. Surv. Bull. 398, pl. 37, fig. 2; CLARK, 1929, Strat. Faunal Hor. Coast Ranges Calif., pl. 43, figs. 2, 4; ETHERINGTON, 1931, Univ. Calif. Publ., Bull. Dept. Geol. Sci. vol. 20, pp. 80–81, pl. 8, figs. 4, 5; WEAVER, 1943, Univ. Wash. Publ. Geol., vol. 5, pp. 162–164, pl. 36, figs. 8, 9, 13; pl. 37, fig. 8; pl. 39, fig. 15.

Venus parapodema DALL, *ibid.*, pl. 11, fig. 11; pl. 13, fig. 1.

Venus (*Chione*) *securis*, GRANT and GALE, 1931, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 320, pl. 17, fig. 1.

Chione parapodema, WEAVER, 1943, Univ. Wash. Publ. Geol., vol. 5, p. 164, pl. 37, figs. 6, 7.

Very close to *S. ensifera*, distinguished from it only on basis of outline; being somewhat thinner and longer, with beaks less inflated; posterior dorsal slope straighter.

Dimensions of hypotype.—No. 31961, length 76 mm., height 65 mm.

Holotype.—(Of *securis*, lost), U. S. Nat. Mus. no. 143944 (*V. parapodema* Dall), Coos Bay, Oregon.

Hypotypes.—No. 31961, Wildcat formation, Humboldt County, California; no. 36100, loc. A 88 (Coos Bay, Oregon), Empire formation, Pliocene; no. 36099, loc. 3322 (Coos Bay, Oregon), Empire formation, Pliocene.

Distribution.—Pliocene, Wildcat formation of California, Astoria and Empire formations of Oregon and Washington.

SECURELLA VANCOUVERENSIS
(Clark and Arnold)
Plate 95, figures 11, 22

Chione vancouverensis CLARK and ARNOLD, 1923, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 14, p. 147, pl. 20, figs. 1, 2; WEAVER, 1943, Univ. Wash. Publ. Geol., vol. 5, p. 168, pl. 39, figs. 5, 6, 11; pl. 40, fig. 1.

The types are small and somewhat eroded, strongly resembling *S. cryptolineata;* differing only in having a narrower ligamental groove.

Dimensions of holotype.—Length 40 mm., height 36 mm.

Holotype.—Stanford Univ. Paleo. Type Coll. no. 246 (not Univ. Calif. Coll. Invert. Pal. no. 30052 as stated in original description); paratype no. 584 Calif. Acad. Sci. Paleo. Coll.

Distribution.—Upper Oligocene, Sooke formation of Vancouver Island, British Columbia.

* * *

SPECIES INCORRECTLY ASSIGNED TO *Chione*

What has hitherto been referred to as *Chione fluctifraga* (Sowerby) (pl. 89, fig. 7; pl. 5, fig. 6; pl. 94, fig. 1) is in the author's opinion not a *Chione* but a *Protothaca*. Although the hinge of *Protothaca fluctifraga* fits the general dental formula of a *Chione*, it does not fall into any of the recognized subgeneric groups, and more closely resembles *P. grata* or *P. staminea*, in that it has a wide and long nymph plate. It has neither escutcheon nor lunule, features well-developed in all chiones. The marginal crenulations are continuous; in *Chione* they are not. In the young stage neither the shell outline nor the ornamentation are like those of *Chione*, but do resemble *Protothaca*. In *Chione* the posterior dorsal slope of the right valve overlaps the left value; in *P. fluctifraga* they abut against each other.

Chione columbiensis (Sowerby) (pl. 94, figs. 14, 16; pl. 95, fig. 9) is considered to be a *Protothaca* for the same reasons, namely, the nature of the hinge and nymph plate, and the fact that the outline and sculpture is more typical of *Protothaca* than *Chione*.

Chione cathcartensis Weaver is a *Macrocallista*. *Venus* (*Chione*) *conradiana* Anderson may be referred to *Clementia*. *Chione mathewsonii* Gabb is probably an *Amiantis*. *Chione whitneyi* Gabb is a *Dosinia*.

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PLIOCENE OSTRACODA FROM SOUTHERN CALIFORNIA

ROBERT W. CROUCH
Richfield Oil Corporation, Bakersfield, California

ABSTRACT—The distribution of 28 species and one variety of Ostracoda found in the Pliocene sediments that crop out in southern California has been studied. Five new species, *Krithe galei*, *Loxoconcha helenae*, *Cytheropteron newportense*, *Trachyleberis semitranslucens*, and *Leguminocythereis microdenticulata* are described. This study is based upon the identification of 4841 specimens.

INTRODUCTION

THE only person to publish upon investigations of fossil ostracodes in southern California is Le Roy (1943). He described 23 new species and 2 new varieties from 18 localities. Only 10 of these localities are Pliocene, and one of them has since been made inacessible by the construction of a drainage ditch. Four of Le Roy's Pliocene localities were visited by the writer and three new Pliocene ostracode localities were discovered. The purpose of investigating the Le Roy localities was to complete the identification of all the previously described species, to establish relative abundance of the several species, and to discover new species.

The species having the widest geographic distribution are as follows: *Brachycythere lincolnensis*, *Hemicythere jollaensis*, *Hemicythere ? californiensis*, *Hemicythere ? californiensis* var. *hispida*, and *Loxoconcha lenticulata*. All of these species occur at 6 of the 7 collecting localities.

The following species were found to be restricted to one locality: *Bairdia verdesensis*, *Caudites fragilis*, *Trachyleberis schencki*, *Leguminocythereis microdenticulata*, *Paradoxostoma ensiforme*, and *Anomocytheridea* cf. *A. inornata*.

Table 1 shows the detailed distribution of all of the Pliocene ostracodes from this region.

Large quantities of material must be collected in order to determine the relative abundance of the Pliocene ostracodes. Equal amounts of unwashed material were collected from The University of Southern California localities 101, 102, 109, and 110. About four times as much was collected from localities 103 and 108 and eight times as much from locality 104.

All holotype and paratype specimens have been deposited in the Paleontological Collection of The University of Southern California.

ACKNOWLEDGMENTS

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LOCALITIES

USC-101. Middle Pliocene. (Le Roy locality No. 1.) San Diego formation, Pacific Beach, La Jolla Quadrangle, San Diego County, California. At the sea cliff, 200 yards north of Diamond Street. Ostracodes common.

USC-102. Upper Pliocene. (Le Roy locality No. 4.) Santa Barbara formation. Base of exposure at bath house, Bath House Beach, City of Santa Barbara, Santa Barbara County, California. Scaled 5.05 inches north and 3.20 inches east from the southwest corner of the quadrangle. Ostracodes abundant.

USC-103. Upper Pliocene. (Le Roy locality No. 9.) Newport Bay, Tustin Quad-

TABLE 1.—NUMBER AND DISTRIBUTION OF PLIOCENE OSTRACODA

Species	Localities							Age		
	101	102	103	104	108	109	110	P*	MP*	UP*
Anomocytheridea cf. *A. inornata* Stephenson	—	—	2	—	—	—	—	—	—	x
Bairdia verdesensis Le Roy	2	—	—	—	—	—	—	—	x	—
Brachycythere driveri Le Roy	—	135	5	24	—	—	—	x	—	x
Brachycythere lincolnensis Le Roy	132	66	21	—	22	4	3	x	x	x
Bythocypris elongata Le Roy	3	—	—	—	4	—	—	x	x	—
Caudites fragilis Le Roy	6	—	—	—	—	—	—	—	x	—
Cytherelloidea californica Le Roy	—	16	3	—	3	1	—	x	—	x
Cytheridea ? pedroensis Le Roy	—	—	3	—	5	1	—	x	—	x
Cytheropteron newportense Crouch, n. sp.	—	—	4	—	12	—	—	x	—	x
Cytheropteron pacificum Le Roy	—	—	13	—	55	2	1	x	—	x
Hemicythere ? californiensis Le Roy	84	336	85	113	239	32	—	x	x	x
Hemicythere ? californiensis var. *hispida* Le Roy	2	70	13	2	6	5	—	x	x	x
Hemicythere jollaensis Le Roy	30	210	23	33	—	1	1	x	x	x
Krithe galei Crouch, n. sp.	—	5	45	—	3	—	—	x	—	x
Leguminocythereis corrugata Le Roy	8	—	—	—	2	—	—	x	x	—
Leguminocythereis microdenticulata Crouch, n. sp.	—	—	—	115	—	—	—	x	—	—
Loxoconcha helenae Crouch, n. sp.	—	—	—	—	7	—	—	x	—	—
Loxoconcha lenticulata Le Roy	13	217	7	30	2	4	—	x	x	x
Paracypris pacificus Le Roy	—	—	5	2	9	—	—	x	—	x
Paracytheridea granti Le Roy	85	100	7	—	2	—	—	x	x	x
Paradoxostoma ensiforme Brady	—	2	—	—	—	—	—	—	—	x
Trachyleberis diegonensis (Le Roy)	14	23	1	—	6	1	—	x	x	x
Trachyleberis glauca (Skogsberg)	33	860	27	35	—	17	—	x	x	x
Trachyleberis kewi (Le Roy)	8	75	11	—	2	10	—	x	x	
Trachyleberis microreticulata (Le Roy)	—	27	—	—	—	—	—	—	—	x
Trachyleberis pennata (Le Roy)	—	142	—	—	—	—	1	x	—	x
Trachyleberis schencki (Le Roy)	5	—	—	—	—	—	—	—	x	—
Trachyleberis semitranslucens Crouch, n. sp.	—	22	4	3	3	1	—	x	—	x
Trachyleberis simiensis (Le Roy)	—	—	375	14	557	24	6	x	—	x
Totals	425	2,336	654	371	939	105	12			

NOTE: P* = Undifferentiated Pliocene; MP* = Middle Pliocene; UP* = Upper Pliocene.

rangle, Orange County, California. Scaled 2.95 inches north and 1.00 inch east from the southwest corner of the quadrangle. Ostracodes common.

USC-104. Undifferentiated Pliocene. (Le Roy locality No. 11.) Near abandoned site of Standard Oil Company's Well, Vickers No. 2–10. Baldwin Hills, Hollywood Quadrangle, Los Angeles County, California. Scaled 0.85 inch north and 2.65 inches east from the southwest corner of the quadrangle. Ostracodes rare.

USC-108. Undifferentiated Pliocene. Newport Bay, Tustin Quadrangle, Orange County, California. Scaled 3.05 inches north and 1.0 inch east from the southwest corner of the quadrangle. Ostracodes common.

USC-109. Undifferentiated Pliocene. San Diego formation. On east side of Newport Bay, along Palisades Road, Newport Beach Quadrangle, Orange County, California. Scaled 8.70 inches north and 0.55 inch west from the southeast corner of the quadrangle. Ostracodes rare.

USC-110. Undifferentiated Pliocene. San Diego formation. On east side of Newport Bay, along Palisades Road, Newport Beach Quadrangle, Orange County, California. Scaled 7.90 inches north and 1.10

inches west from the southeast corner of the quadrangle. Ostracodes rare.

Order OSTRACODA Latreille
Suborder PODOCOPA Sars
Family CYTHERIDAE Baird, 1850

Genus *Krithe* Brady, Crosskey, and Robertson, 1874.

Genotype.—*Cytherideis bartonensis* Jones, 1855, Palaeontographical Soc., London, vol. 9, part 2, p. 50, pl. 5, figures 2a, 2b, 3a, 3b.

KRITHE GALEI Crouch, n. sp.
Plate 96, figure 6

Description.—Carapace of female rhomboidal in side view; greatest height slightly posterior to middle, greatest thickness medial; dorsal margin strongly arched, slightly convex anterior to middle, then curved upward to its highest point slightly posterior to the middle, then curved downward in an unbroken curve to the acute posterior ventral angle; dorsal margin straight to slightly sinuous; valves rather strongly convex; generic internal structure.

Dimensions.—Right valve, length, 0.72 mm.; height, 0.40 mm.; thickness, both valves, 0.30 mm.

Types.—The University of Southern California Paleontological Collection: holotype no. 125; paratype no. 126.

Type locality.—USC locality 103. Upper Pliocene.

Comparisons.—This species differs from *Krithe perattica* Alexander (1934) by having a sinuous ventral margin and a convexity on the anterior dorsal margin.

Remarks.—The carapace of the male is similar to the female in outline. The dorsal margin is not as strongly arched as in the female, and the greatest height is medial. The male also lacks the strong convexity of the valves.

This species is named for Dr. H. R. Gale.

Genus ANOMOCYTHERIDEA Stephenson, 1948

Genotype.—*Cytheridea floridana* Howe and Hough, 1935, Florida Dept. Cons., Geol. Bull. 13, p. 10–11, pl. 2, figures 15, 16, 18; pl. 4, figures 6, 10.

ANOMOCYTHERIDEA cf. A. INORNATA
Stephenson, 1938
Plate 96, figure 5

1938. *Anomocytheridea inornata* STEPHENSON, Jour. Paleontology, vol. 12, no. 2, p. 142–143, pl. 23, figs. 17, 19; text fig. 14.

Remarks.—M. B. Stephenson, in a personal communication, expressed the opinion that this form closely resembles his species, *Anomocytheridea inornata.*

Occurrence.—USC locality 103. Upper Pliocene.

Genus LOXOCONCHA G. O. Sars, 1865

Genotype.—*Loxoconcha bairdi* Müller, 1912, Das Tierreich, vol. 31, p. 306, figure 85.

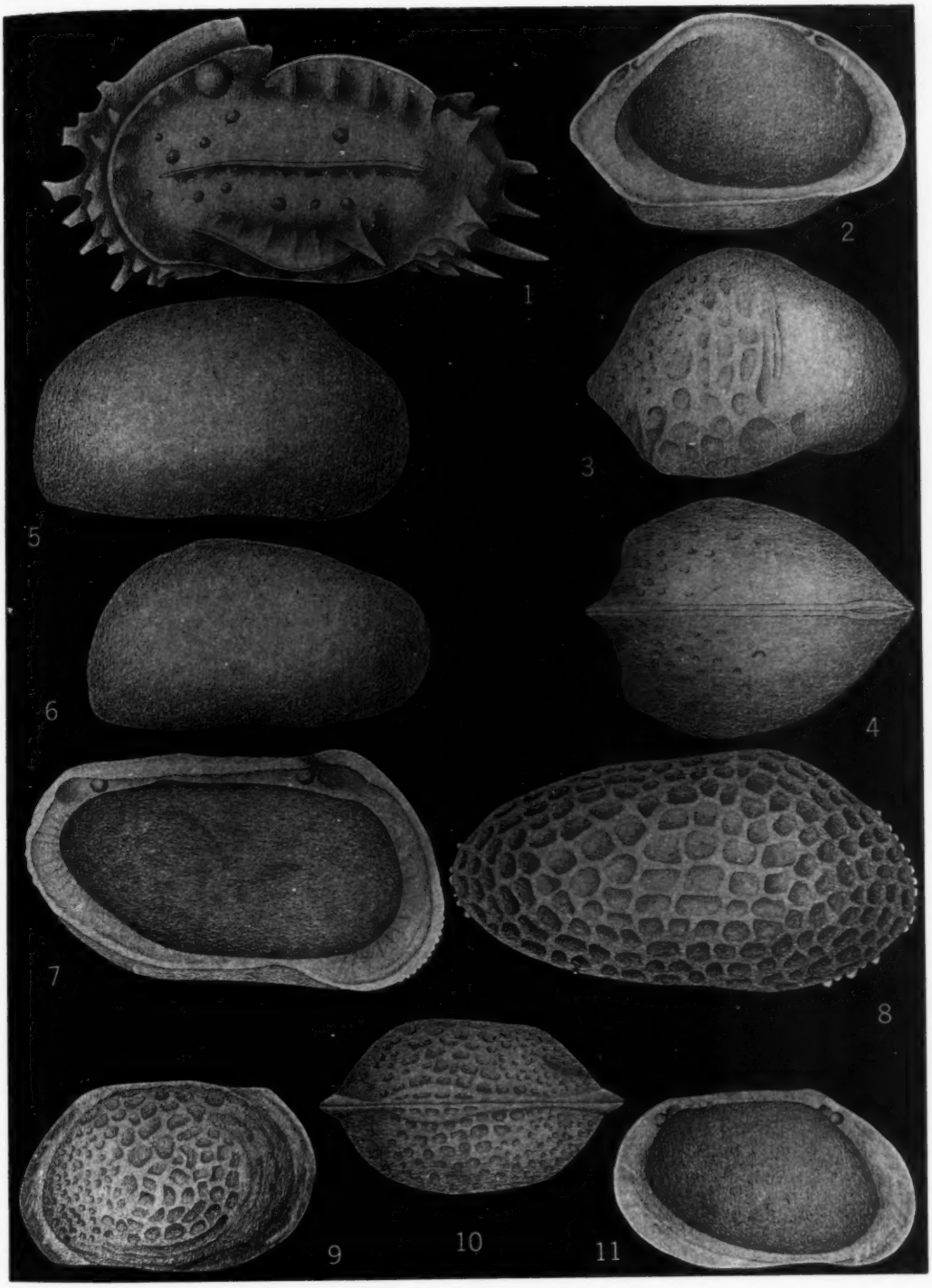
LOXOCONCHA HELENAE Crouch, n. sp.
Plate 96, figures 9–11

Description.—Carapace in side view quadrate and elongate, of equal height; dorsal margin straight, ventral margin almost straight, slightly convex; anterior and posterior margins broadly obliquely rounded; greatest thickness slightly posterior to middle; bar finely crenulate; teeth and sockets very small; surface ornamented by numerous subrounded pits, decreasing in size from center of carapace toward the margins; greatest convexity is ventral and posterior; the carapace rises abruptly from near the margin leaving a narrow marginal shelf; the ventral portion of this tumid region has two faint anterior-posterior wrinkles; radial pore canals indistinct.

Dimensions.—Left valve, length, 0.52 mm.; height, 0.30 mm.; thickness, both valves, 0.25 mm.

EXPLANATION OF PLATE 96

FIG. *1*—*Trachyleberis semitranslucens* Crouch, n. sp. ×72. Left valve, holotype no. 120. (p. 597)
2–4—*Cytheropteron newportense* Crouch, n. sp. ×87. *2*, inside view of left valve, holotype no. 122. *3*, right valve, paratype no. 123. *4*, dorsal view, paratype no. 124. (p. 597)
5—*Anomocytheridea* cf. *A. ornata* Stephenson. ×72. Right valve. (p. 596)
6—*Krithe galei* Crouch, n. sp. ×72. Right valve, holotype no. 125. (p. 596)
7–8—*Leguminocythereis microdenticulata* Crouch, n. sp. ×72. *7*, inside view of left valve, holotype no. 127. *8*, right valve, paratype no. 128. (p. 598)
9–11—*Loxoconcha helenae* Crouch, n. sp. ×87. *9*, left valve, holotype no. 130. *10*, inside view of left valve, paratype no. 131. *11*, dorsal view, paratype no. 132. (p. 596)



Crouch, Pliocene Ostracoda

Types.—The University of Southern California Paleontological Collection: holotype no. 130, paratype nos. 131, 132.

Type locality.—USC locality 108. Undifferentiated Pliocene.

Comparisons.—This species differs from *Loxoconcha lenticulata* Le Roy by its strong pits, anterior-posterior wrinkles, and its greatest thickness being posterior to the middle.

Remarks.—This species is named for Helen Crouch.

Genus CYTHEROPTERON G. O. Sars, 1865

Genotype.—*Cythere latissima* Norman, A. M., 1867, Trans. Nat. Hist. Soc. Northumberland, vol. 1, p. 19, pl. 6, figures 5–8.

CYTHEROPTERON NEWPORTENSE
Crouch, n. sp.
Plate 96, figures 2–4

Description.—Carapace triangular in side view; anterior end broadly obliquely rounded; posterior end bears a short blunt projection; greatest height and thickness medial; ala moderately developed, blunt, slightly rounded, projecting downward and outward; hinge line prominently arched; small sockets barely discernible in right and left valves; teeth not observed; left valve larger, overlaps at dorsal margin; surface ornamented by very faint, irregular shallow pits, 8 or 9 pits extending along the midline from the dorsal to ventral side.

Dimensions.—Left valve, length, 0.55 mm.; height, 0.40 mm.; thickness, both valves, 0.40 mm.

Types.—The University of Southern California Paleontological Collection: holotype no. 122; paratype nos. 123, 124.

Type locality.—USC locality 108. Undifferentiated Pliocene.

Comparisons.—This species differs from *Cytheropteron pacificum* Le Roy in having a blunt ala, heavier carapace, and irregular shallow pits.

Family TRACHYLEBERIDAE Sylvester-Bradley, 1948

Subfamily TRACHYLEBERINAE Sylvester-Bradley, 1948

Genus TRACHYLEBERIS Brady, 1898

Genotype.—*Cythere scabrocuneata* Brady, 1880, Report of the Scientific Results of the Voyage of H.M.S. Challenger, vol. 1, p. 103, pl. XVII, figures 5a–f, pl. XXIII, figures 2a–c.

TRACHYLEBERIS DIEGONENSIS (Le Roy), 1943

1943. *Cythereis diegonensis* LE ROY, Jour. Paleontology, vol, 17, no. 4, p. 369, pl. 58, figs. 26–31; text figure 2e.

Occurrence.—Pliocene and Pleistocene.

TRACHYLEBERIS GLAUCA (Skogsberg), 1928

1928. *Cythereis glauca* SKOGSBERG, Calif. Acad. Sci., p. 110, pl. 3, figs. 2, 6, 7; pl. 4, fig. 4.
1943. *Cythereis glauca*, LE ROY, Jour. Paleontology, vol. 17, no. 4, p. 368, pl. 61, figs. 19–23; pl. 62, figs. 11, 12, text figures 2v, w.

Occurrence.—Pliocene to Recent.

TRACHYLEBERIS KEWI (Le Roy), 1943

1943. *Cythereis kewi* LE ROY, Jour. Paleontology, vol. 17, no. 4, p. 369, pl. 60, figs. 24–27; pl. 62, figs. 9, 10; text figure 2d.

Occurrence.—Pliocene to Recent.

TRACHYLEBERIS MICRORETICULATA (Le Roy), 1943

1943. *Cythereis microreticulata* LE ROY, Jour. Paleontology, vol. 17, no. 4, p. 370, pl. 59, figs. 17–22; text figure 2n.

Occurrence.—Upper Pliocene.

TRACHYLEBERIS PENNATA (Le Roy), 1943

1943. *Cythereis pennata* LE ROY, Jour. Paleontology, vol. 17, no. 4, p. 370, pl. 59, figs. 34–37; pl. 62, figs. 19–20; text figure 2h.

Occurrence.—Pliocene.

TRACHYLEBERIS SCHENCKI (Le Roy), 1943

1943. *Cythereis schencki* LE ROY, Jour. Paleontology, vol. 17, no. 4, p. 371, pl. 58, figs. 9–14; text figure 2n.

Occurrence.—Pliocene and Pleistocene.

TRACHYLEBERIS SEMITRANSLUCENS
Crouch, n. sp.
Plate 96, figure 1

Description.—Carapace subquadrangular in side view, narrower posteriorly than anteriorly; rim irregular, anterior end heavy, dorsally it swings in a broad flattened arch anteriorly forming a dorsal lip with the ventral margin, then swings somewhat sharply around the posterior end, then straight to the point of origin; anteriorly there is a crest starting with an anterior dorsal notch; it swings in keeping with the rim and dorsal and ventral margin and terminates before the sharp anterior swing; anterior rim crest bears 8 pronounced spines and 8 smaller ones directly above them; just

above the posterior rim there are 8 long spines, directly above them are 6 or 7 indistinct spines; a main crest originates in a notch just posterior to the first flange notch, then follows the outline of the first crest and continues around the posterior end and terminates in a posterior ventral notch; a third crest begins at this notch and swings dorsally in a broad arch to the point of origin; a prominent ridge runs along the midline and occupies the central two-thirds of the length of the carapace; a fourth and very high crest swings ventrally on the ventral side of the mid-flange to form a spoon-shaped structure; it has 5 short carinae running down its dorsal surface and one very prominent spine protruding ventroposteriorly; a rather prominent minutely pitted eye tubercle lies ventral to the second notch; scattered tubercles dot the surface of the carapace; generic internal structure.

Dimensions.—Left valve, length, 1.00 mm.; height, 0.52 mm.; thickness, both valves, 0.44 mm.

Types.—The University of Southern California Paleontological Collection: holotype no. 120, paratype no. 121.

Type locality.—USC locality 102. Upper Pliocene.

Comparisons.—The new species is slightly similar to *Trachyleberis kewi* (Le Roy) in outline, but distinguished from it by its many flanges, median ridge, and spoon-shaped structure on the ventral surface.

Remarks.—This species has been observed by the writer in Recent sediments from Cristóbal Bay, Baja California. The young molt stages are extremely fragile and transparent and lack the medial ridge. In place of the ridge there are small nodes. The minutely pitted eye tubercle is lacking and appears only in the more advanced molt stages.

Genus LEGUMINOCYTHEREIS Howe, 1936

Genotype.—Leguminocythereis scarabaeus Howe and Law, 1936, Louisiana Dept. Cons. Geol. Bull. 7, pp. 61, 63, 64, pl. 4, figures 12, 17, pl. 5, figures 15–17.

LEGUMINOCYTHEREIS MICRODENTICULATA Crouch, n. sp.
Plate 96, figures 7–8

Description.—Carapace elongate in side view, posterior dorsal margin is more sharply rounded than the posterior ventral margin; greatest height is at right angles to anterior socket; greatest thickness posterior to middle; hinge line almost straight, shallowly channeled; dorsal margin straight, ventral margin concave just anterior to middle; overlap prominent, left valve overlaps ventral periphery; bar slightly convex; right valve with sharp anterior tooth, small rounded postjacent socket, narrow grooved margin merging with very high, smooth, elongate tooth; hinge of left valve with deep posterior socket bordered by small, rounded elevated margin and by slightly elongate anterior socket; surface ornamented with numerous large pits of equal size; deepening of the pits on the ventral side causes several ventral posterior-anterior wrinkles; posterior margin slightly denticulate.

Dimensions.—Left valve, length, 0.95 mm.; height, 0.55 mm.; thickness, both valves, 0.45 mm.

Types.—The University of Southern California Paleontological Collection: holotype no. 127; paratype nos. 128, 129,

Type locality.—USC locality 104. Undifferentiated Pliocene.

Comparisons.—This species is similar to *Leguminocythereis corrugata* Le Roy, but lacks the characteristic surface ridges. Although it was found only at its type locality, it is very abundant there.

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 6, PP. 600–612, PLS. 97–99, 3 TEXT FIGS., NOVEMBER 1949

SOME MISSISSIPPIAN CEPHALOPODS FROM CENTRAL AND WESTERN UNITED STATES

A. K. MILLER, H. R. DOWNS,
State University of Iowa, Iowa City, Iowa,
AND WALTER YOUNGQUIST
University of Idaho, Moscow, Idaho

ABSTRACT—Eight small collections of Mississippian cephalopods from seven states are discussed, and the better specimens are figured. A new species of *Triboloceras* is established for a rather well preserved internal mold from the Lower Mississippian of Kentucky. For the first time, a fully mature representative of the genotype of *Endolobus* is illustrated—it came from the type Chester of Illinois. The Chouteau limestone of Missouri has yielded two exceptional nautiloids that are dealt with in this study— one is an essentially complete individual belonging in *Triboloceras* and the other is a unique specimen for which the generic name *Brittsoceras* is proposed. The second goniatite to be found in the Fern Glen formation of Missouri and Illinois is described—it represents a new species of *Imitoceras*. The discovery of a large *Rayonnoceras* in the Pitkin limestone of Arkansas is recorded. *Mooreoceras, Thoracoceras?, Poterioceras, Liroceras?, Triboloceras,* and possibly *Munsteroceras* are recognized in blocks of chert from the upper part of the Redwall limestone of Arizona, and it is concluded that this cephalopod assemblage is indicative of an early Mississippian age. The occurrence of cephalopods at two new localities in the White Pine shale of Nevada is documented; the genera represented are *Mooreoceras, Epicanites?, Goniatites, Lyragoniatites?, Girtyoceras,* and *Anthracoceras?*. Finally, specimens belonging in *Girtyoceras* and *Cravenoceras?* are described from the Heath formation of Montana.

FAIRLY recently, several small collections of Mississippian cephalopods from Kentucky, Illinois, Missouri, Arkansas, Arizona, Nevada, and Montana have become available to us for study. Although none of these is particularly important in itself, collectively they seem to add considerably to our knowledge of the faunas and the strata involved. Some of them are not very closely related; but, nevertheless, as a matter of expediency, we are combining a discussion of the entire lot into a single publication.

Acknowledgement is due to the following persons for the loan of the specimens on which most of this report is based: Professors G. E. Condra and M. K. Elias of The University of Nebraska; Mr. Warren R. Eshbaugh of the University of Missouri; Professor R. C. Gutschick of the University of Notre Dame; Dr. F. L. Humphrey of Stanford University; Mr. John Britts Owen of Clinton, Missouri; Mr. W. E. Schevill of Harvard University; and Professor Harold W. Scott of the University of Illinois. The photographs which accompany this study were retouched by Mr. Howard E. Webster of Iowa City, and he also drew the text figures. The completion of the manuscript and the illustrations was made financially possible by the Graduate College of the State University of Iowa.

A *TRIBOLOCERAS* FROM KENTUCKY

Ward's Natural Science Establishment, Inc., of Rochester, New York, sent to the senior author for identification a nautiloid that represents a new species of *Triboloceras*, and it was purchased by the State University of Iowa. The label which accompanies this specimen indicates that it came from Carboniferous strata in or near Farmers, northeastern Kentucky, but nothing further is known in regard to its derivation. It is the first representative of the genus to be described from the state, and therefore we propose the following name for it:

TRIBOLOCERAS KENTUCKIENSE Miller, Downs, and Youngquist, n. sp.
Plate 97, figure 4

The holotype of this species is an internal

mold that is moderately well preserved but not very complete. Nevertheless, it represents most of one of the lateral zones of the conch, and its maximum over-all diameter measures about 96 mm.

The conch, when complete, appears to have consisted of considerably more than two volutions. In the adapical part of the preserved portion, the cross section is more or less subcircular. However, during ontogeny there was developed a prominent broad rounded ventrolateral concave zone, which gives the conch the appearance of having a lateral keel (accentuated near the adoral end by a very slight concave zone immediately dorsad of it) and an elevated ventral zone (that bore a few coarse longitudinal ribs and intermediate grooves at full maturity). The cross section near the adapical end of the outer volution, insofar as it can be ascertained, is shown by text figure 1, with the inferred part indicated by a dashed line.

At least the adoral quarter-volution is non-septate and represents the living chamber. The extreme adoral part of the preserved portion of it may not have been in contact with the preceding volution. The surface of the internal mold bears longitudinal lirae which become rather widely spaced orad. Traces of the growth lines on the concave ventrolateral zone near the adoral end of the specimen curve strongly apicad as they approach the venter, indicating that there was a deep hyponomic sinus, which was probably rounded.

The camerae are moderately short, and there are about 28 of them to the volution. The sutures, though directly transverse, are slightly sinuous, forming distinct lobes as they cross the concave ventrolateral (and probably also the dorsal) zones and the ventral grooves. No trace of the siphuncle can be discerned.

Remarks.—This species seems to us to differ considerably from all of the previously described representatives of the genus. It is perhaps closest to *T. digonum digonum* (Meek and Worthen) of the Rockford limestone of Indiana and the Chouteau and Northview formations of Missouri. However, in that form the conch is relatively low and broad and the ventral zone is not prominently elevated. *T. digonum magnum* Miller and Furnish, a large form from the Chouteau of Missouri, is also superficially similar to the new species but in cross section is quite different.

Occurrence.—The only known representative of this species was found in or near Farmers, Rowan County, Kentucky. It is partially imbedded in a small block of fine-grained brownish gray sandstone which contains no other fossils. Specimens that are referable to the genus *Triboloceras* have also been collected in Indiana, Illinois, Missouri, New Mexico, and Arizona, as well as in western Europe and Soviet Russia. In at least all of its North American occurrences (except possibly that in Arizona) the strata which carry it are believed to be referable to the Lower Mississippian Kinderhook group or series, and presumably the bed which yielded the specimen just described is of the same general age. However, the genus may, of course, be found to have a somewhat greater range and to occur, for example, in the overlying Osage group, from which relatively few cephalopods have been described.

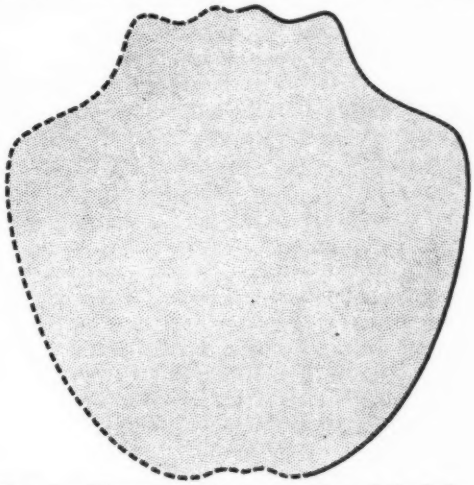


FIG. 1 —Diagrammatic cross section of the holotype of *Triboloceras kentuckiense* Miller, Downs, and Youngquist, ×2.

Holotype.—State University of Iowa, 13898.

AN *ENDOLOBUS* FROM THE TYPE CHESTER

Through the courtesy of W. E. Schevill of Harvard University, a representative of the genus *Endolobus* from the Mississippian

strata at or near Chester, Illinois, has become available to us for study. It appears to be referable to *E. spectabilis* (Meek and Worthen), the genotype of *Endolobus*. The importance of this specimen is greatly enhanced by the fact that the only representative of the species that has been illustrated heretofore is believed to be a "young" individual.

The specimen under consideration (see plate 98, fig. 1) is a moderately well preserved internal mold of the right half of the adoral half-volution of the phragmacone and the adjacent part of the living chamber of an individual that was more than 36 cm. in diameter (its present over-all maximum measurement). The conch is nautiliconic in its mode of growth and is more or less subglobular in shape. The whorls are depressed dorsoventrally, broadly rounded ventrally, more narrowly rounded laterally, and considerably impressed dorsally—they are much more strongly arched ventrally than dorsally (impressed zone disregarded). Near the mid-length of the preserved portion of the phragmacone of this specimen, the conch is a little more than 10 cm. high and its corresponding width is estimated to have been approximately twice that amount.

The lateral zone of the specimen bears a single row of large prominent rounded nodes, of which there are six in a half-volution. The camerae are moderate in length, and there are fourteen of them in the adoral half-volution of the phragmacone. The two adoral camerae of this individual are considerably shorter than the preceding ones, indicating that it had attained full maturity. Each suture forms a broad rounded ventral saddle, similar but narrower ventrolateral lobes, and a deep V-shaped but narrowly rounded dorsal lobe; but the course across the umbilical walls is essentially straight and directly transverse. Near the mid-length of the adapical half of the preserved part of the living chamber, there is a structure some 10 mm. in diameter that appears to represent the siphuncle, which apparently is subcentral (being distinctly nearer the venter than the dorsum) and is orthochoanitic (being composed of cylindrical segments).

The label which accompanies this specimen indicates that it was collected by A. H. Worthen and was identified by Alpheus Hyatt as "*Temnocheilus spectabilis*," which is now generally regarded as the genotype of *Endolobus*. That is, in 1865 Meek and Worthen established the genus *Endolobus* and placed in it only the holotype of their species, *Nautilus* (*Endolobus*) *peramplus* of the Chester of Illinois. That form then became the type of the genus. However, the following year these authors concluded that the large specimen ("greatest diameter, 23 inches"), for which they had coined that specific name, is conspecific with a much smaller individual (about 4½ inches in diameter) from the same general horizon and locality, for which they had earlier proposed the name *Nautilus spectabilis;* and they therefore suppressed their later name in favor of the one that has priority. The specimen for which the name *Nautilus* (*Endolobus*) *peramplus* was proposed has never been illustrated, and its whereabouts is unknown to us. Therefore, we are unable to confirm or reject Meek and Worthen's conclusion in regard to its specific affinities; but the specimen we are studying appears to us to be conspecific with the holotype of *E. spectabilis*, and both are from the Chester group or series of Randolph County, Illinois.

It should perhaps be added that the specimen described above is the property of the Harvard Museum of Comparative Zoology, where its catalogue number is 4109. It is preserved in light brownish gray argillaceous limestone.

TWO EXCEPTIONAL NAUTILOIDS FROM THE CHOUTEAU LIMESTONE OF MISSOURI

John Britts Owen of Clinton, Missouri, loaned us two specimens that he collected fairly recently from the Chouteau limestone of his home state, and both of them clearly deserve to be illustrated and described. One is by far the most nearly complete representative of the genus *Triboloceras* that has so far been found in North America, at least; and the other does not seem to be referable to any previously recognized genus or species. For a general treatment of the Chouteau nautiloids, the reader is referred to Miller and Furnish's report of 1939 on the "Lower Mississippian nautiloid cephalopods of Missouri."

TRIBOLOCERAS DIGONUM PENTAGONUM
Miller and Furnish
Plate 97, figures 6, 7

Triboloceras digonum pentagonum MILLER and FURNISH, 1939 [1938], Missouri Univ. Studies, vol. 13, no. 4, pp. 154–155, 188, pl. 39, figs. 5, 6; pl. 43, fig. 5.

The specimen under consideration is an internal mold that is moderately well preserved but is firmly imbedded in a block of hard light gray finely crystalline limestone. It consists of a little more than two and a half volutions; and its maximum diameter, measured from the adoral end of the preserved portion of the ventral side across the umbilicus, is a little less than 100 mm.

The adapical part of the specimen is not well preserved; but clearly it was loosely coiled and the umbilical perforation was large. Almost certainly this portion of the conch did not differ greatly from that of *T. digonum subcirculare* M. & F., illustrated by Miller and Furnish (1939, pl. 39, fig. 7). Not until the conch had completed almost two volutions, did its whorls come in contact, and at no stage of ontogenetic development was it appreciably involute. Furthermore, the adoral part of the living chamber of the individual we are studying diverges considerably from the preceding whorl.

The adoral third of the outer volution of this specimen is non-septate and presumably, therefore, represents the living chamber. The shape of the cross section at full maturity is shown by figure 6 on plate 97, with the inferred parts indicated by a dashed line—the measurements on which this drawing was based were taken somewhat orad of the junction of the phragmacone and the living chamber. Attention should perhaps be called to the fact that the ventral side is grooved medianly, the ventrolateral zones are subangular, and the dorsolateral ones are rounded.

The surface of the internal mold bears prominent longitudinal lirae, which became progressively farther apart throughout ontogenetic development. The camerae are moderately short, and there are about 14 or 15 of them in the adoral half-volution of the phragmacone of the specimen being studied. The sutures form broad rounded lateral lobes and low rounded dorsolateral saddles, but their course across the dorsal and the ventral zones of the conch is not visible. Also, the nature and position of the siphuncle are not revealed.

Remarks.—In cross section, the holotype of *T. digonum pentagonum* is somewhat lower and broader than is the individual just described, and also the type seems to have steeper and somewhat better defined umbilical walls. Nevertheless, a direct comparison of these two specimens seems to us to indicate that their similarities are more pronounced and therefore perhaps more significant than their differences.

Occurrence.—Chouteau limestone in the Stewart-Nattinger quarry, Milo Parks farm, E½ NE¼ sec. 34, T. 40 N., R. 26 W., Henry County, Missouri. The holotype, the only previously known representative of this variety, came from the same formation near Iconium, St. Clair County, Missouri.

Repository.—Private collection of John Britts Owen of Clinton, Missouri.

Genus BRITTSOCERAS Miller, Downs, and Youngquist, n. gen.

Genotype.—Brittsoceras ornatissimum Miller, Downs, and Youngquist, n. sp.

Conch moderately small, nautiliconic, subdiscoidal, and composed of only a few whorls. These are subcuneiform in cross section as they are higher than wide, rounded ventrally, somewhat impressed dorsally, and flattened laterally, and the lateral zones converge dorsad. Umbilicus large, open, and perforate; and umbilical shoulders rounded and indefinite. Each ventrolateral zone bears a single row of prominent rounded nodes which are transversely elongate. Surface of test conspicuously reticulate. Nature of septa, sutures, and siphuncle unknown.

The new genus, which is named in honor of John Britts Owen, resembles somewhat *Temnocheilus* M'Coy, and the two are probably related. However, in typical representatives of M'Coy's genus, the whorls are low and broad, the ventrolateral nodes are longitudinally elongate, and the test does not bear prominent longitudinal lirae.

The single form that we are referring to *Brittsoceras*, the genotype, has so far been found in only the Lower Mississippian Chouteau limestone of Missouri.

BRITTSOCERAS ORNATISSIMUM Miller
Downs and Youngquist, n. sp.
Plate 97, figures 1–3

The specimen on which this species is based is a rather well preserved testiferous individual, which however does not retain the internal structures of the conch. It consists of a little more than two and a half volutions, and its maximum diameter measures about 32 mm. Near the mid-length of the adoral half-volution of this holotype, the conch is about 10 mm. high and attains a corresponding maximum width (not including the nodes) of some 8 mm. Its general physiognomy and the shape of the cross section are shown by the accompanying illustrations.

On each of the ventrolateral zones of the conch there are 12 or 13 transversely elongate nodes to the volution. Throughout ontogenetic development, these nodes increased in size progressively, but their prominence remained fairly constant. The surface of the test bears conspicuous longitudinal and transverse lirae and is therefore reticulate. The transverse lirae curve slightly apicad as they cross the ventral zone of the conch, and may therefore be said to suggest the presence of a broad shallow rounded hyponomic sinus. No trace of either the sutures or the siphuncle can be discerned in the specimen for which we are establishing this species.

Remarks.—Inasmuch as this form is the only known representative of the genus, specific comparisons would be superfluous.

Occurrence.—Chouteau limestone in James River bluff about ¼ mile upstream from bridge and about 1 mile west of Turners Station, Green County, Missouri.

Repository.—Private collection of John Britts Owen of Clinton, Missouri.

A GONIATITE FROM THE TYPE SECTION OF THE OSAGIAN FERN GLEN FORMATION OF MISSOURI

Early in June of 1948, Warren R. Eshbaugh found a goniatite in the Fern Glen limestone at Fern Glen Station, about 20 miles west of St. Louis, Missouri. Only one other ammonoid, the holotype of *Imitoceras pfefferae* Miller and Werner, is known from that formation—it came from near Valmeyer, Illinois, some 25 miles south of St. Louis. Furthermore, the entire Osage group, of which the Fern Glen is the basal portion, has yielded few ammonoids indeed. Therefore, this specimen seems to merit special consideration. Though it is probably referable to Schindewolf's genus *Imitoceras*, as now interpreted, it does not belong in any described species, and we are naming it in honor of its discoverer.

IMITOCERAS ESHBAUGHI Miller,
Downs, and Youngquist, n. sp.
Plate 99, figure 11

The single specimen on which this species is being based is an internal mold that is slightly distorted and is only moderately well preserved in light red argillaceous limestone. Its maximum diameter measures a little more than 70 mm. Most of its adoral volution appears to be non-septate and presumably therefore represents the living chamber.

The conch as a whole is subdiscoidal in shape, and the whorls are strongly compressed, narrowly rounded ventrally, almost

EXPLANATION OF PLATE 97

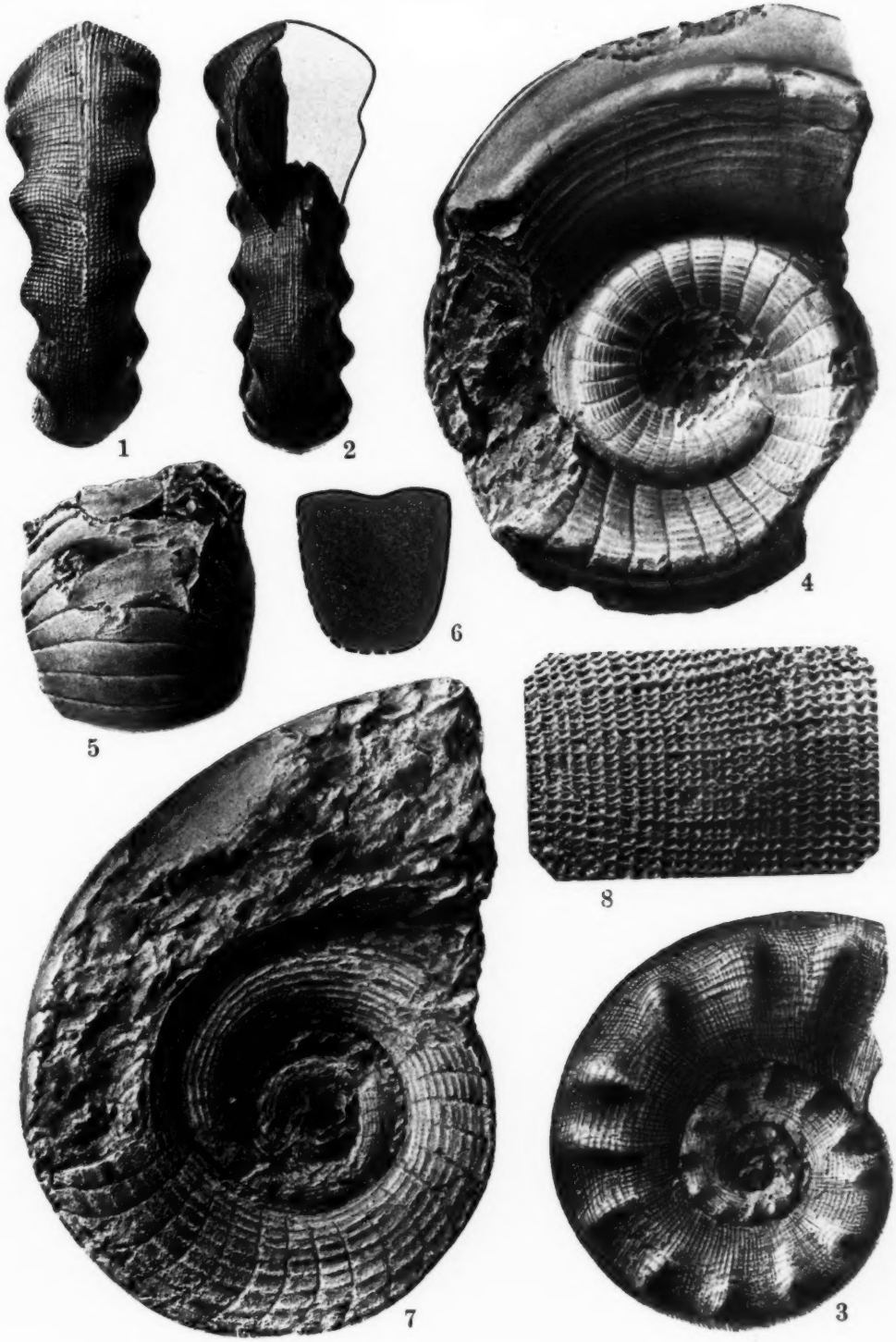
FIGS. *1–3—Brittsoceras ornatissimum* Miller, Downs, and Youngquist, n. sp. Three views of the holotype, from the Chouteau limestone about 1 mile west of Turners Station, Missouri, ×2. (p. 604)

4—Triboloceras kentuckiense Miller, Downs, and Youngquist, n. sp. Lateral view of the holotype, from the Lower Mississippian at or near Farmers, Kentucky, ×1. (p. 600)

5—Liroceras? sp. Ventral view of an internal mold of portions of eight camerae of a phragmacone, from the Redwall limestone just northwest of Jerome, Arizona, ×1. (p. 607)

6, 7—Triboloceras digonum pentagonum Miller and Furnish. Diagrammatic cross section (of the adapical portion of the living chamber) and lateral view of an almost complete internal mold, from the Chouteau limestone on the Milo Parks farm in Henry County, Missouri, ×1. (p. 603)

8—Lyragoniatites? sp. Enlargement of a ventrolateral portion of the test (at a diameter of some 20 mm.) of a specimen, from the White Pine shale about 5 miles west-southwest of Mt. Hamilton, White Pine County, Nevada, ×10. (p. 610)



Miller, Downs and Youngquist, Mississippian Cephalopoda

2

1

Miller, Downs and Youngquist, Mississippian Cephalopoda

flat laterally, and deeply impressed dorsally. The lateral zones, which appear to be almost parallel, are distinctly convex exteriorly, and the maximum width of the conch is attained slightly dorsad of the mid-height of the whorls. Near the adapical end of the outer volution of the holotype, the conch is about 20 mm. high and has a corresponding width of about 11 mm.

The umbilicus is large, and its diameter is equal to a little less than half that of the conch. The maximum diameter attained by the umbilicus of the holotype is about 30 mm. The umbilical shoulders are abruptly rounded, and the umbilical walls, though low, are moderately steep. No trace of the surface markings of the test can be discerned on the holotype. As shown by text

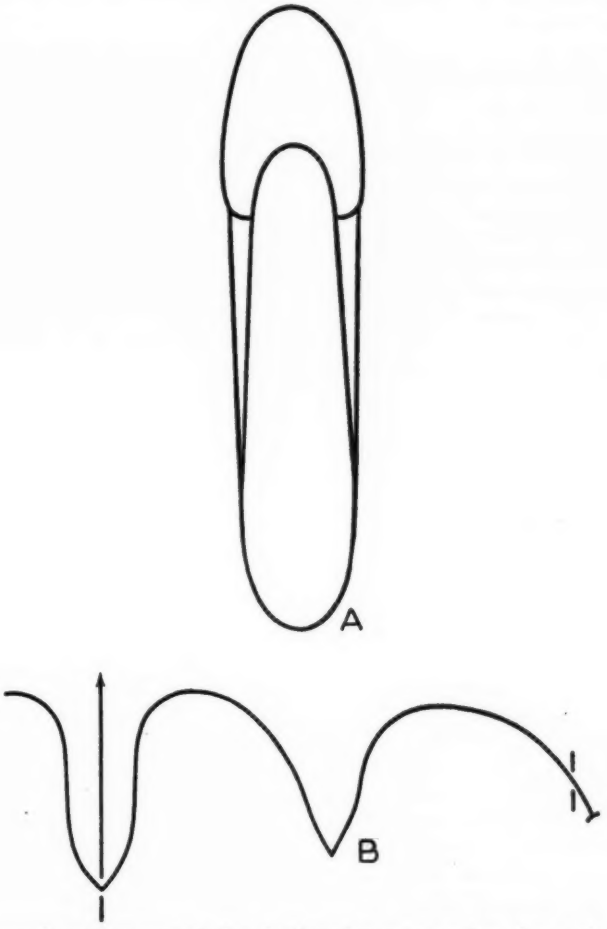


FIG. 2.—Diagrammatic outline ventral view (×1) and representation of one of the adoral sutures (×3) of the holotype of *Imitoceras eshbaughi* Miller, Downs, and Youngquist, n. sp.

EXPLANATION OF PLATE 98

FIGS. *1*—*Endolobus spectabilis* (Meek & Worthen). Lateral view of a mature specimen, from the Chester series at or near Chester, Illinois, ×½. (p. 601)

2—*Rayonnoceras* sp. A large incomplete internal mold, from the Pitkin limestone about ½ mile east of Leslie, Arkansas, ×¼. (p. 606)

figure 2B, each mature external suture forms a large deep hastate ventral lobe, and on either side of it an asymmetrically U-shaped first lateral saddle, a V-shaped first lateral lobe, and a broadly rounded second lateral saddle which extends clear to the umbilical seam. The shape of the internal sutures was not ascertained.

Remarks.—This species is not very similar to the genotype of *Imitoceras*, *Ammonites rotatorius* de Koninck of the early Lower Carboniferous (Tournaician) of western Europe, from which it differs particularly in that its umbilicus is large and open and its conch is more strongly compressed. Nevertheless, it seems to be more closely related to it than to any other valid genotype. The only other ammonoid known from the Fern Glen formation, *I. pfefferae*, also has an open umbilicus, which, however, is considerably smaller than that of the new species. The Lower Mississippian Chouteau limestone of Missouri and the Lower Carboniferous strata of Europe have yielded congeneric forms in which the umbilici are not closed, but none of them is very close to the one we are studying.

Occurrence.—The holotype of *I. eshbaughi* was found in a boulder from a talus slope at Fern Glen, St. Louis County, Missouri. This boulder also contained an orthoceraconic nautiloid. Its lithology is stated to indicate that it came from the upper portion of a calcareous "layer that roughly separates the red from the yellow part" of the Fern Glen formation at this locality.

Holotype.—Private collection of Warren R. Eshbaugh of the University of Missouri.

A RAYONNOCERAS FROM THE PITKIN LIMESTONE OF ARKANSAS

In 1940 G. E. Condra and M. K. Elias found a large straight nautiloid in the Pitkin limestone of north-central Arkansas, and through their kindness it was made available to us for study. This specimen appears to be referable to *Rayonnoceras*, and it is the first representative of that genus to be recorded from the formation (see Easton, 1942, pp. 84–86, for a list of the Pitkin fauna).

The specimen under consideration (plate 98, figure 2) is an internal mold to which adheres a replacement of a large fragment of the test. It is incomplete both orad and apicad, is only moderately well preserved, and is somewhat crushed. Nevertheless, it was almost certainly circular (or nearly so) in cross section, and it was gradually and regularly expanded orad. Its maximum over-all length measures about 41½ cm. and its maximum width about 19 cm.

Near the mid-length of the specimen, the test was about 3½ mm. thick. No trace of its surface markings is discernible.

This specimen is septate throughout its entire length, and it represents portions of 18 camerae of a phragmacone. The sutures are essentially straight and directly transverse.

At a break near the adapical end of the specimen, it can be seen that the siphuncle is central (or nearly so) in position and that its diameter measures about 23 mm. at its passage through a septum (which itself is about 135 mm. in diameter). The septal necks are strongly recurved, and the segments of the siphuncle are greatly expanded within the camerae and are broadly nummuloidal in shape.

The preservation of this specimen, and particularly that of its siphuncle, leaves much to be desired. We are therefore uncertain in regard to its specific affinities, but it appears to be considerably larger than any congeneric form that has previously been found in America (but not in Europe). Also, it may well be the youngest. It is preserved in dark gray crystalline limestone, which weathers light brownish gray. It came from a quarry on the south side of the highway about half a mile east of Leslie, Searcy County, Arkansas; and it is to be deposited in the collections of the Nebraska Geological Survey.

A CEPHALOPOD FAUNA FROM THE REDWALL LIMESTONE OF ARIZONA

In central Arizona, R. C. Gutschick collected some blocks of fossiliferous chert from the upper part of the Redwall limestone, and thirty of them, which contain cephalopods, were kindly loaned to us for study. Some of the specimens are external molds (from which we have made casts with a latex compound), others are internal molds, and a few are in part both. All are fragmentary and incomplete, and they leave

much to be desired. Nevertheless, it is clear that the fauna contains many nautiloids and a few ammonoids.

Of the former, thirteen are more or less nondescript, moderately small, essentially smooth orthocones that are subcircular or broadly subelliptical in cross section and, in at least some cases, have small siphuncles which are not marginal in position. These are being lumped together and labelled *Mooreoceras* spp., though it is recognized that some of them almost certainly are not congeneric with the type species of that genus. Six similar specimens have prominent longitudinal ridges, and we are placing them with question in *Thoracoceras*. Two others, which appear to be slightly curved, are rapidly expanded orad, and they probably belong in *Poterioceras*. The fragment illustrated by figure 5 on plate 97 is part of an internal mold of a smooth subglobular tightly coiled phragmacone on which the external sutures are only slightly sinuous, and it is tentatively being referred to *Liroceras* (though its internal sutures appear to form broad dorsal saddles). The remaining six nautiloids (including those represented by figures 12–15 on plate 99) are the most significant of the lot, and we are identifying them with little hesitation as *Triboloceras digonum semicirculare* Miller and Furnish, which was originally described from the Chouteau limestone of Missouri (where it is of widespread occurrence) and which has since been found in the Caballero formation of New Mexico. *T. digonum* (Meek and Worthen) has previously been known from only the Rockford limestone of Indiana, the Chouteau and Northview formations of Missouri, equivalent beds in Illinois, and the Caballero of New Mexico. Congeneric forms were long ago illustrated and described from western Europe and Soviet Russia, and the discovery of one in northeastern Kentucky is recorded elsewhere in the present report. At least all the American representatives of this genus, of which the age is definitely known, came from the Lower Mississippian, that is, the Kinderhook group or series.

Only two ammonoids are present in the Redwall collections under consideration, and both of them are small external molds that are less than 15 mm. in diameter. Casts of these show that the conch, was subdiscoidal in shape; that the whorls were compressed, broadly rounded laterally, rather narrowly rounded ventrally, and much higher than wide; that the umbilicus was small but was almost certainly not closed; and that the internal sutures consist of a deep narrow spatulate dorsal lobe and on either side of it a high rather narrow U-shaped saddle, a relatively short more or less V-shaped lateral lobe, and a low broad rounded saddle that extends to the umbilicus. These internal sutures, the nature of the umbilicus, and the shape of the conch suggest a relationship to *Munsteroceras* (which is characteristic of Kinderhook-Tournaician strata), but because the external sutures of the Redwall specimens are unknown, their generic affinities can not be ascertained.

Gutschick has written us that all the cephalopods under consideration came from the uppermost member (approximately 64 feet thick) of the Redwall limestone in the fault scarp at Jerome Hill (SW¼ sec. 21, T. 16 N., R. 2 E.) about a quarter to half a mile northwest of Jerome, Yavapai County, Arizona. He indicates that locally the top of the hill is covered with many fragments of fossiliferous rust-colored chert from this member, and these yielded, in addition to the cephalopods, representatives of the following genera: *Endothyra*, *Amplexus?*, *Syringopora*, *Zaphrentis?*, *Camarotoechia*, *Composita*, *Cranaena?*, *Dielasma*, *Nucleospira*, *Rhipidomella*, *Shumardella*, *Conocardium*, *Myalina*, *Bellerophon*, *Loxonema*, *Straparolus*, *Spirorbis*, and *Paraparchites*. Furthermore, he states that in the immediately underlying member, which consists principally of about 91 feet of light gray coarsely crystalline abundantly fossiliferous limestone, he found representatives of the genera *Syringopora*, *Hapsiphyllum*, *Buxtonia*, *Rhipidomella*, *Spirifer*, *Loxonema*, and *Straparolus;* and he believes this member to be Osagian (Burlington) in age, whereas he regards the underlying portions of the formation as belonging in the Kinderhook.

Our studies have been confined to the cephalopods. Taken by themselves, they seem to us to indicate that the containing beds are Kinderhookian in age and are the approximate correlative of the Caballero,

the Northview, the Chouteau, and the Rockford. None of the specimens militate against this conclusion. However, all of them are incomplete, and the great majority are not very satisfactory to study. Furthermore, it should be kept in mind that very few cephalopods are known from typical Osagian strata, and therefore future collecting may show that the forms on which we are relying have a longer range than we now suspect.

The collection on which the above discussion is based is to be deposited at the University of Notre Dame.

SOME CEPHALOPODS FROM TWO NEW LOCALITIES IN THE WHITE PINE SHALE OF NEVADA

Since the completion of Youngquist's recently published report on "The cephalopod fauna of the White Pine shale of Nevada," and the supplement thereto, Fred L. Humphrey has sent in two small collections of cephalopods from localities at which no specimens had been secured previously. Most of the material is rather fragmentary and poorly preserved in crystalline calcite, and it is firmly imbedded in blocks of hard limestone.

However, from one of the localities, which is along the western edge of the White Pine Mountains, about three-quarters of a mile east of Green Springs and some eight miles south of Mount Hamilton, we have been able to recognize *Mooreoceras* sp., *Goniatites choctawensis* Shumard, and *Girtyoceras* aff. *G. meslerianum* (Girty). The single specimen that we are referring to the genus *Mooreoceras* is an internal mold of a portion of a straight phragmacone that is circular (or nearly so) in cross section, is about 30 mm. long, and has a maximum diameter of about 12 mm.; its siphuncle is small (at least at its passage through the septa) and is not quite central in position. Of the two goniatites that we were able to remove from the matrix, the one represented by figures 7 and 8 on plate 99 seems to be a typical representative of *Goniatites choctawensis;* it is completely septate, and it has a maximum diameter of almost 11 mm. and a corresponding width of conch of about 10½ mm.—the shape of its sutures is elucidated by text figure 3A. The goniatite portrayed by figures 9 and 10 on plate 99 is similar to equal-sized representatives of the genotype of *Girtyoceras, G. meslerianum* (Girty). The adoral portion of this specimen is crushed, but its maximum diameter (in its present state) measures about 13 mm. The surface of its test bears rather prominent growth-lines which form shallow lateral and ventral sinuses; these are essentially parallel to sinuous transverse constrictions present on the internal mold (and possibly also on the exterior of the test, where they are, however, not very prominent). The sutures, shown by text figure 3C, are in general similar to those of *G. meslerianum* but have a somewhat narrower ventral lobe and a narrowly rounded (rather than a pointed) lateral lobe. All of these specimens (and others that are too poorly preserved to permit identification) are from

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EXPLANATION OF PLATE 99

FIGS. *1–4—Girtyoceras* aff. *G. meslerianum* (Girty). Two views of each of two specimens from the basal portion of the Heath formation on the northern flank of the Big Snowy Mountains of central Montana, ×5 and ×3, respectively. (p. 611)

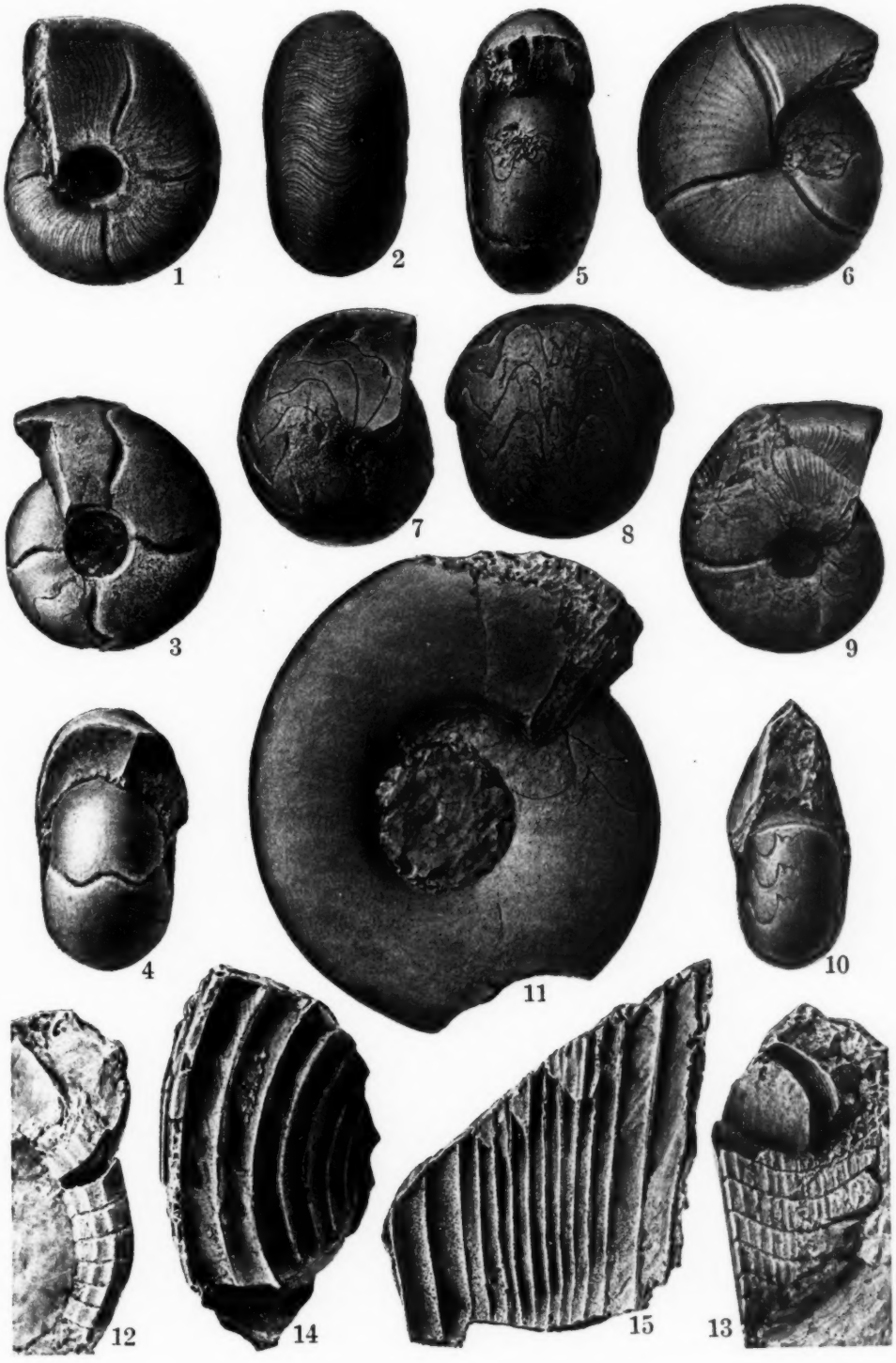
5, 6—Anthracoceras? humphreyi Miller, Downs, and Youngquist, n.sp. The holotype, from the White Pine shale about 5 miles west-southwest of Mt. Hamilton, White Pine County, Nevada, ×2. (p. 610)

7, 8—Goniatites choctawensis Girty. Lateral and ventral views of a well preserved completely septate internal mold from the White Pine shale about ¾ mile east of Green Springs, White Pine County, Nevada, ×3. (p. 608)

9, 10—Girtyoceras aff. *G. meslerianum* (Girty). Lateral and apertural views of a small testiferous specimen (the adoral portion of which is crushed) from the same horizon and locality as the last, ×3. (p. 608)

11—Imitoceras eshbaughi Miller, Downs, and Youngquist, n. sp. The holotype, from the Fern Glen formation at Fern Glen, Missouri, ×1. (p. 604)

12–15—Triboloceras digonum semicirculare Miller and Furnish. Two views of each of two specimens (figs. *14, 15* represent an artificial cast) from the Redwall limestone just northwest of Jerome, Arizona, ×1½. (p. 607)



Miller, Downs and Youngquist, Mississippian Cephalopoda

blocks of hard black finely crystalline limestone, collected from the upper portion of the White Pine shale about three-quarters of a mile east of Green Springs; that is, about eight miles south of Mount Hamilton, White Pine Mountains, White Pine County, Nevada. They are to be deposited in the U. S. National Museum.

The other collection under consideration came from a locality about 5 miles west-southwest of Mount Hamilton (of White Pine Range) along a road in the valley between the Pancake and White Pine ranges, in White Pine County. It consists of representatives of *Mooreoceras, Epicanites?, Lyragoniatites?, and Anthracoceras?*. We are placing in *Mooreoceras* a large smooth fragment of an orthoceracone (that is about 50 mm. long and a little more than 20 mm. wide) and several smaller specimens some of which have prominent fine transverse lines—none of these show the nature of the sutures or the siphuncle, and therefore even their generic affinities can not be ascertained with certainty. One small goniatite, which is firmly imbedded in the matrix, is only about 5 mm. in diameter, but nevertheless it forms five full volutions; the nature of its sutures is not revealed, but its general physiognomy suggests a relationship to *Epicanites*. Three or four of the goniatites are fragmentary and not very well preserved but nevertheless retain part of the surface ornamentation of the test (see pl. 97, fig. 8), and it is reticulate and is reminiscent of that of *Lyragoniatites*. Also, the conch of this

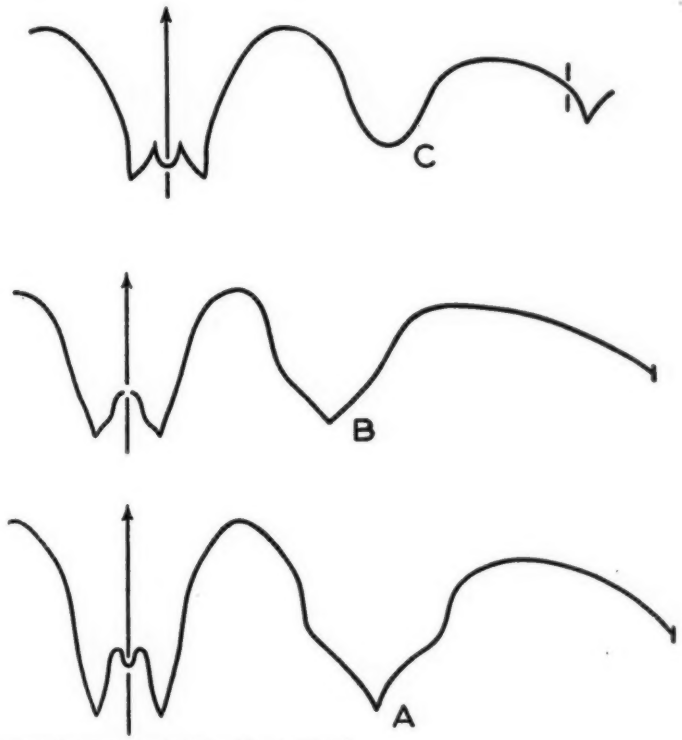


FIG. 3—Diagrammatic representations of sutures of:
A, *Goniatites choctawensis* Shumard, based on the specimen represented by figures 7, 8 on plate 99 at a diameter of about 10 mm., ×8;
B, *Anthracoceras? humphreyi* Miller, Downs and Youngquist, n. sp., based on the holotype (pl. 99, figs. 5, 6) at a diameter of about 13 mm., ×7; and
C, *Girtyoceras* aff. *G. meslerianum* (Girty), based on the specimen represented by figures 9, 10 on plate 99 at a diameter of about 8 mm., ×10.

form is moderately large (attaining a diameter of at least 45 mm.) and is subglobular in shape, as in *Lyragoniatites*, but, unlike typical representatives of that genus, the White Pine form has a very small umbilicus, which is probably closed. Its internal sutures consist of a narrow spatulate dorsal lobe, a rounded U-shaped first lateral saddle, a V-shaped first lateral lobe, and a broad rounded saddle that extends to the umbilicus. However, its external sutures are unknown; and because of this fact, the small umbilicus, and the fragmentary nature and incompleteness of the specimens, we are unable to determine the generic affinities with a reasonable degree of certainty—possibly they are with *Goniatites* de Haan or *Neoglyphioceras* Brünning. All of the specimens discussed in this paragraph are preserved in hard black finely crystalline limestone; they came from the same horizon and locality as those we are describing below as a new species of *Anthracoceras?;* and they are to be deposited in the U. S. National Museum.

The several genera represented in the two Nevada collections under consideration are characteristic of a cephalopod fauna that is of widespread occurrence in the United States, being known from various localities in the White Pine shale of Nevada and California, the "Middle Mississippian" of Utah (Bacon, 1948, p. 1037), the Helms formation of west Texas, the Barnett shale of north-central Texas, the Caney shale of Oklahoma, the Moorefield-Ruddell-Batesville-Fayetteville beds of Arkansas, the "Meramec" of Kentucky (Miller and Furnish, 1940, pp. 356–366, pls. 45, 46), and the Rome shale of Georgia. The exact age of this fauna is difficult to determine because only the basal portion of the Mississippian system carries a variety of cephalopods in its type area, the upper Mississippi Valley. Tentatively, we consider the containing beds to be of Meramec age.

ANTHRACOCERAS? HUMPHREYI Miller, Downs, and Youngquist, n. sp.
Plate 99, figures 5, 6

The holotype of this species is a fairly complete rather well preserved internal mold which is about 21 mm. in diameter. It is subdiscoidal in shape as its whorls are flattened laterally, rather narrowly rounded ventrally, and deeply impressed dorsally. At the adoral end of the holotype. the conch is about 12 mm. high and 10 mm. wide. The preserved portion of the living chamber is a little more than three-quarters of a volution in length. The umbilicus is small, inconspicuous, and closed, and the umbilical shoulders are rounded and indefinite.

The surface of the internal mold, where well preserved, appears smooth to the naked eye, but even at low magnification it can be seen to contain numerous closely spaced small shallow rounded pits so that it is reminiscent of the "runzelschicht" of nautiloids. The outer volution of the holotype bears three prominent rounded sinuous constrictions which form broad very shallow rounded lateral salients and similar but narrower ventral sinuses—the adoral constriction is much larger than the other two. Also, on the surface of this internal mold there are traces of the increments of growth; they likewise form broad rounded lateral salients and narrower ventral sinuses, but they are not quite parallel to the constrictions and are somewhat more strongly sinuous.

As shown by text figure 3B, each external suture consists of a moderately large bifid ventral lobe, and on either side of it a narrowly rounded first lateral saddle, a rather large more or less V-shaped pointed first lateral lobe, and a broadly rounded saddle which extends to the umbilicus. The shape of the internal sutures is not known.

Remarks.—The collection we are studying contains a rather poorly preserved specimen that is of about the same size and shape as the above-described holotype and is almost certainly conspecific with it. The fact that both of these specimens, from the same horizon and locality, are of approximately the same size, suggests that they are mature individuals.

This species does not seem to us to be very close to the genotype of *Anthracoceras, Dimorphoceras* (*Anthracoceras*) *discus* Frech of the Middle Carboniferous of central Europe, nor to any other genotype. Nevertheless, the general physiognomy of its conch and the shape of its sutures are similar to those of *A. discus*, and the chief difference is in the surface markings of the test, the taxonomic significance of which is question-

able. Accordingly, we are tentatively referring the new species to Frech's genus *Anthracoceras*, but are using an interrogation mark to call attention to our uncertainty in regard to its generic affinities. Comparisons with other species do not seem to be necessary, for none are very similar.

Occurrence.—White Pine shale about 5 miles west-southwest of Mount Hamilton along a road going down the valley between the White Pine and Pancake ranges, White Pine County, Nevada.

Types.—U. S. National Museum.

GONIATITES FROM THE HEATH FORMATION OF MONTANA

Harold W. Scott loaned us for study about a dozen small ammonoids which he collected from the basal few feet of the Heath formation in the Big Snowy Mountains of central Montana. Most of these are almost certainly immature, and all but five of them are firmly imbedded in blocks of hard black limestone, which is abundantly fossiliferous.

All of the free specimens and the great majority of those still imbedded in matrix seem to be referable to *Girtyoceras*, and they are similar to equal-sized representatives of the type species of that genus, *G. meslerianum* (Girty). In addition, two fragmentary external molds (which may represent only one individual) suggest an affinity with *Cravenoceras* of the type of *C. hesperium* and *C. nevadense*, both of Miller and Furnish. *Girtyoceras* and *Cravenoceras* are known to occur in association in the White Pine shale of Nevada, the Barnett formation of Texas, the Caney shale of Oklahoma, and probably the upper Viséan at various localities in western Europe and the British Isles. Presumably the containing beds at all of these widely separated localities, and those in Montana, are not greatly different in age, and it is believed that the American ones are probably referable to the Meramec group.

The largest of the specimens that we are identifying as *Girtyoceras* aff. *G. meslerianum* is illustrated by figures 3 and 4 on plate 99. Its maximum diameter measures about 12½ mm., and near its adoral end its conch is about 6 mm. high and has a corresponding width of about 7 mm. The volutions are helmet-shaped in cross section, being rounded ventrally, flattened laterally, and rather deeply impressed dorsally. The umbilicus is open, and its diameter is equal to about two-sevenths that of the specimen. The umbilical shoulders are abruptly rounded, and the umbilical walls are very steep. The surface of the outer volution of this specimen, an internal mold, bears four prominent sinuous rounded transverse constrictions which form rounded ventral and lateral sinuses and ventrolateral salients—they seem to extend to the umbilical shoulders but not to continue onto the umbilical walls. The adoral third of the outer volution of this specimen is septate, and as shown by text figure 4, each suture forms a moderately deep, more or less V-shaped but bifid ventral lobe and on either side of it a broad rounded first lateral saddle, a depressed-V-shaped but narrowly rounded lateral lobe, and a rather low rounded saddle which extends to a small subangular lobe on the umbilical wall.

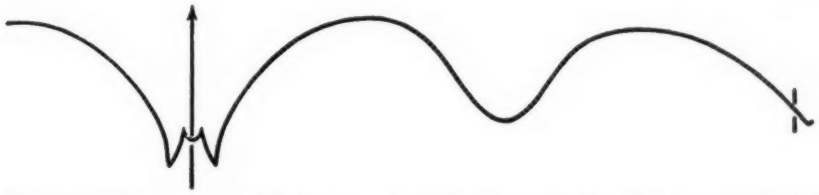


FIG. 4—Diagrammatic representation of a suture of *Girtyoceras* aff. *G. meslerianum* (Girty), based on the specimen represented by figures 3, 4 on plate 99 at a diameter of about 8½ mm., ×15.

The relatively small conspecific individual (about 8 mm. in diameter) illustrated by figures 1 and 2 on plate 99 shows the nature of the surface markings of the test. The growth lines are fine and numerous and they are parallel to the sinuous transverse

constrictions which affect the exterior of the test as well as the internal mold, but are more prominent on the latter. Other small specimens in the collection under consideration also retain the test, or rather a replacement of it, and they show similar growth lines and sinuous constrictions.

Except for the details of the sutures, these specimens do not seem to us to differ materially from typical representatives of *Girtyoceras meslerianum* in our collections from the Caney shale of Oklahoma, which yielded the syntypes. However, the ventral lobe of the sutures in the Caney specimens is much broader and the first lateral saddles are much narrower (cf. Miller and Furnish, 1940, text fig. 11 on p. 367).

The two fragments that are being referred with question to *Cravenoceras* are external molds of the ventral and ventrolateral portions of a form in which the conch attained both a diameter and a width of at least 10 mm. It was broadly rounded ventrally and ventrolaterally and almost certainly subglobular in shape, and its surface was marked by fine rather distantly spaced almost straight transverse lines. No trace of the sutures is present on either of these specimens, but the general physiognomy of the conch and particularly the nature of the surface markings of the test are reminiscent of *C. hesperium* and *C. nevadense* of the White Pine shale of Nevada.

All of these specimens came from about 404 feet above the base of the Big Snowy group, that is, the basal portion of the Heath formation (zone 8 of Scott, 1935, p. 1025) on the northern flank of the Big Snowy Mountains in sec. 6, T. 12, N., R. 20 E., Fergus County, Montana. One of the unfigured representatives of *Girtyoceras* is being deposited at the State University of Iowa, where its catalogue number is 8108. The other specimens become the property of the University of Illinois, where they are numbered X-1450 (pl. 99, figs. 1–4), X-1451 (*Cravenoceras?* sp.), and X-1452 (unfigured representatives of *Girtyoceras*).

Some 30 miles to the southwest, in the eastern portion of the Little Belt Mountains, Scott collected from beds that almost certainly also belong in the basal portion of the Heath formation a few small and probably immature goniatites that appear to represent the same fauna. They are all less than 10 mm. in diameter, their preservation leaves much to be desired, and they do not reveal their sutures. Nevertheless, in general physiognomy and in the nature of their sinuous transverse constrictions, they do not seem to differ materially from equal-sized specimens from the same formation in the Big Snowy Mountains, which we are identifying as *Girtyoceras* aff. *G. meslerianum* (Girty). They came from about 304 feet above the base of the Big Snowy group about 4 miles due west of Judith Gap, Wheatland County, Montana; and they are to be deposited at the University of Illinois, where they will be numbered X-1453.

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THE CEPHALOPOD FAUNA OF THE WHITE PINE SHALE OF NEVADA: SUPPLEMENT

WALTER YOUNGQUIST
University of Idaho, Moscow, Idaho

ABSTRACT—Subsequent to the completion of the larger report on the White Pine cephalopod fauna, several additional forms, some of them not previously recorded from the White Pine shale, have been made available for study. These specimens were collected from two localities in the White Pine Mountains and are referable to the genera *Mooreoceras*, *Cravenoceras*, *Epicanites*, and *Dimorphoceras*. One new species is included.

SINCE the completion of the earlier report on the cephalopod fauna of the White Pine shale, additional material from two new localities in the White Pine Mountains has become available for study through the courtesy of Dr. Fred L. Humphrey. Although only about a half dozen specimens were collected, they represent four genera and one new species. These individuals constitute the basis for this supplement to the earlier and larger report.

The first locality which yielded a part of the present collections is about one mile south of Eberhardt ("Eberhardt Mill" of Hall and Whitfield, 1877), and some 200 yards to the east of the mouth of Sherman Canyon. This locality is the same or very close to the place where Hague secured the White Pine cephalopods described by Hall and Whitfield in 1877. Those authors gave the location as "near Eberhardt Mill, White Pine, Nevada." Humphrey states that the specimens were secured "probably in the upper half of the White Pine shale." From this place a representative of *Cravenoceras hesperium* Miller and Furnish was collected.

The other location is in a "thin lime rib" about 200 feet below the top of the White Pine shale 4500 feet S. 70° E. of Green Springs; that is, about 8 miles south of Mount Hamilton. Here the following cephalopods were obtained:

Mooreoceras spp.
Cravenoceras hesperium Miller and Furnish
Epicanites cf. *E. loeblichi* Miller and Furnish
Dimorphoceras humphreyi, n. sp.

A systematic treatment of these collections follows. All of the specimens have been deposited in the U. S. National Museum.

Acknowledgment is due Dr. Fred L. Humphrey of Stanford University for the loan of these specimens and for supplying pertinent stratigraphic information. Dr. A. K. Miller of the State University of Iowa has contributed technical advice as well as editorial suggestions.

SYSTEMATIC PALEONTOLOGY

MOOREOCERAS spp.

The collections contain two fragmentary representatives of *Mooreoceras*, neither of which merits illustration. Both are internal molds which appear, however, to be specifically distinct. At least the larger one is septate and attained a minimum length of 41 mm.

Occurrence.—White Pine shale near Green Springs, about 8 miles south of Mount Hamilton, White Pine County, Nevada.

Repository.—U. S. National Museum.

CRAVENOCERAS HESPERIUM Miller and Furnish

Plate 100, figures 1–7

Nuculoceras incisum [part] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 29, 30, 33, 106–108, 109, 113, 383, 384, 399, pl. 7, figs. 7–9, 11–14 [not 10].

Nuculoceras barnettense [part?] PLUMMER and SCOTT, 1937, Texas Univ. Bull. 3701, pp. 15, 33, 106, 108–109, 110, pl. 7, figs. 15–18.

Cravenoceras hesperium MILLER and FURNISH, 1940, Jour. Paleontology, vol. 14, pp. 366, 373, 374–375, pl. 46, figs. 1–8.

Cravenoceras hesperium MILLER and YOUNGQUIST?, 1948 Jour. Paleontology, vol. 22, pp. 651–653, 656, pl. 95, figs. 7–9, 13, 14.

Cravenoceras hesperium YOUNGQUIST, 1949, Jour. Paleontology, vol. 23, pp. 278, 279, 281, 291, pl. 59, figs. 4–16; pl. 60, figs. 1, 2, 8–15; pl. 61, figs. 1–3, 10–12; pl. 62, figs. 1–6, 16–18; text fig. 1B.

Three well preserved individuals from two localities in the White Pine Mountains are referable to this species. The largest of these (figure 4), which came from near Eberhardt, preserves at least a full volution of living chamber and attains a maximum diameter of 29 mm. No traces of the sutures are visible. At the adoral end of the outer volution, the conch is about 19 mm. wide and 10 mm. high. The umbilical shoulders are abrupt and the umbilical walls are steep. The maximum width of the umbilicus is some 9 mm., that is, slightly less than a third the diameter of the conch. Although the test is not retained, traces of the growth lines are preserved on the internal mold. These indicate that they are transverse and form slight ventrolateral sinuses and shallow dorsolateral and ventral salients. There are four transverse constrictions on the outer volution of the conch; each constriction is about 2 mm. wide and parallels the growth lines.

The second largest specimen (figures 5–7) is completely septate and has a diameter of 10 mm. Maximum diameter of the umbilicus is 3 mm. The height and width of the adoral portion of the conch is about 4 mm. and 8 mm., respectively. This individual resembles the largest specimen just described in all details except that there are only two constrictions on the outer volution of the conch. Representatives of *Cravenoceras* usually show an increase in the number of constrictions per volution in ontogenetic development and since this specimen represents a much more immature portion of the conch than does the individual represented by figure 4, the difference in the number of constrictions is readily accountable. In general, constrictions in goniatites are somewhat variable in their occurrence and they appear to have little taxonomic value.

In addition, however, this second specimen bears sutures which are readily discernible. These are typically those of *Cravenoceras;* that is, the ventral lobe is relatively straight sided, and is divided by a small saddle which itself is bifid. The first lateral saddle is rather symmetrically rounded and the first lateral lobe is rather deep and acuminate. The second lateral saddle is asymmetrically rounded and extends to the umbilical shoulder. Just inside the umbilical shoulder there is a small narrow lobe.

The smallest specimen (figures 1–3) is likewise septate throughout and is about 9 mm. in maximum diameter. In all available details it resembles the individual just described except for the presence of three rather than two constrictions on the outer volution of the conch.

Occurrence.—White Pine shale near Green Springs, about 8 miles south of Mount Hamilton (figures 1–3, 5–7); and the same formation about 1 mile south of Eberhardt near the mouth of Sherman Canyon. Both localities are in the White Pine Mountains, White Pine County, Nevada.

Figured specimens.—U.S. National Museum.

DIMORPHOCERAS HUMPHREYI Youngquist, n. sp.
Plate 100, figures 8–11

The holotype of this species, the only representative of *Dimorphoceras* known from the White Pine shale, is preserved as an internal mold. It is septate throughout and the maximum diameter of the conch is about 12 mm. At the adoral end of the outer volution, the conch is 7 mm. wide and 6½ mm. high—being helmet-shaped in cross section. The depth of the impressed zone is approximately 2 mm. The umbilicus is small and closed. Faint traces of growth lines on one portion of the ventrolateral zone of the conch show that there they form a rather prominent ventrolateral salient; presumably they would therefore form lateral and ventral sinuses.

Each suture forms a broad, deep, rather straight-sided ventral lobe which is divided by a high median saddle which in itself is bifid. Each secondary ventral lobe is divided by a low, pointed, asymmetrical, secondary ventral saddle. The first lateral saddle is large, high, and somewhat asymmetrically rounded. This is succeeded by the first lateral lobe which is unequally divided by a small pointed secondary saddle. The second lateral saddle is prominently asymmetrical and continues to the umbilical shoulder. The nature of the internal sutures is not known.

The sutures of *D. humphreyi* distinguish it from other other congeneric forms. Species of *Dimorphoceras* fall into two general categories; the first includes forms in which the lateral lobe is undivided. Examples of this type are *D. gilbertsoni* from the Viséan of

England, and *D. politum* (Shumard) of the lower Pennsylvanian of Illinois, Missouri, and Texas. The second group includes specimens in which the lateral lobe is divided by a small secondary saddle. This category includes *D. discrepans* (Brown) from both the Viséan and Namurian of England, and *D. edwini* Miller and Furnish from the Meramec series of Rockcastle County, Kentucky. *D. humphreyi*, n. sp., belongs in this latter group. However, it differs materially in its sutures from *D. edwini*, particularly in the form of the first lateral saddle, as well as in the height of the primary and secondary saddles which divide the ventral lobe (see text fig. 1). The sutures of *D. humphreyi* most nearly approximate those of *D. discrepans*. Although detailed diagrammatic representations of sutures are not available for *D. discrepans*, it appears that the ventral saddle in that species is somewhat lower than in the White Pine specimen under consideration. In addition, the first lateral saddle of *D. humphreyi* is asymmetrically inclined slightly umbilicad whereas that of *D. discrepans*, and particularly that of *D. edwini* inclines ventrad. Also, the secondary saddles of the ventral lobe of *D. humphreyi*, are appreciably larger than those of the British form.

Occurrence.—White Pine shale near Green Springs, about 8 miles south of Mount Hamilton, White Pine County, Nevada.

Holotype.—U. S. National Museum.

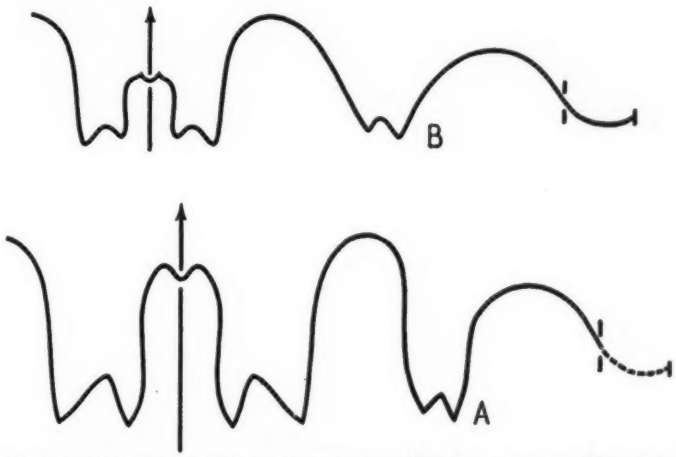

FIG. 1—Suture of (A) the holotype of *Dimorphoceras humphreyi*, n. sp., at a diameter of about 11 mm., from the White Pine shale of Nevada, ×10. (B) Diagrammatic representation (from Miller and Furnish) of one of the adoral sutures of the holotype of *Dimorphoceras edwini* Miller and Furnish, at a diameter of about 8 mm., from the Meramec of Kentucky, ×10.

EPICANITES cf. E. LOEBLICHI Miller and Furnish
Plate 100, figures 12–15

A single specimen in the collection appears to belong in the genus *Epicanites* and to be close to or conspecific with the forms described by Miller and Furnish from the Caney shale of Oklahoma. This White Pine specimen is an internal mold which attains a maximum diameter of slightly more than 21 mm. Near the adoral end of the preserved portion of this individual, the conch is about 7 mm. wide and 8 mm. high. The conch is subdiscoidal in form and the whorls are slightly impressed dorsally. Early portions of the conch appear to be rounded ventrally and broadly rounded laterally; the more nearly mature parts become somewhat flattened laterally and the umbilical shoulders are relatively more distinct. The umbilicus is open and attains a diameter of about 8 mm.—that is, slightly more than a third the maximum diameter of the conch. Very faint traces of growth lines impressed on the internal mold indicate that they were transverse and only slightly sinuous.

In most available details this specimen is in close agreement with *E. loeblichi* of Miller

and Furnish. However, that specimen consisted of about four and one-half volutions at a diameter of 9 mm. This White Pine specimen consists of about the same number of volutions at a diameter of 21 mm. However, since the ultimate volution of this specimen is very rapidly expanded orad this discrepancy is not so great as first appears. That is, at a diameter of only 12 mm., it still consists of four volutions. No sutures are apparent on this individual so that comparisons of that important feature can not be made with the Caney specimens. However, the individual under consideration in gross form at least is very close to the holotype of *E. loeblichi* and it seems likely that the two may be conspecific.

Occurrence.—White Pine shale near Green Springs, about 8 miles south of Mount Hamilton, White Pine County, Nevada.

Figured Specimen.—U. S. National Museum.

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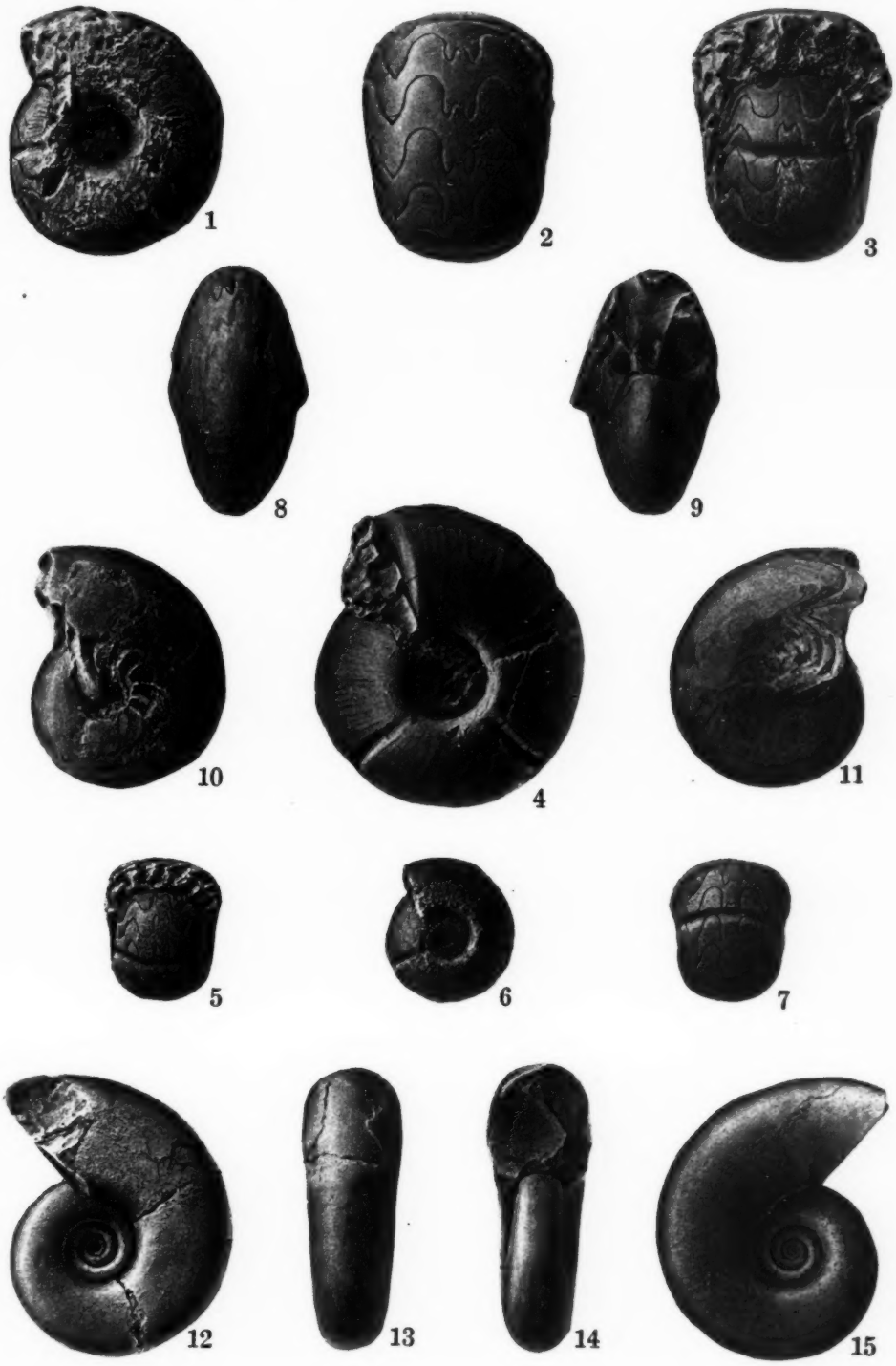
EXPLANATION OF PLATE 100

All specimens are from the White Pine shale in the White Pine Mountains of east-central Nevada. They are deposited in the U. S. National Museum.

FIGS. *1–7*—*Cravenoceras hesperium* Miller and Furnish. Figures *1–3*, 3 views of a small specimen from a locality near Green Springs, about 8 miles south of Mount Hamilton, ×4; figure *4*, an individual retaining the living chamber, from an outcrop about 1 mile south of Eberhardt, ×1½; figures *5–7*, 3 views of a portion of a phragmacone from the same horizon and locality as figures *1–3*, ×2. (p. 613)

8–11—*Dimorphoceras humphreyi*, n. sp. Four views of the holotype from a locality near Green Springs, about 8 miles south of Mount Hamilton, ×3. (p. 614)

12–15—*Epicanites* cf. *E. loeblichi* Miller and Furnish. A single specimen from a locality near Green Springs, about 8 miles south of Mount Hamilton, ×2. (p. 615)



Youngquist, White Pine shale Cephalopoda

JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 6, PP. 617–622, PL. 101, NOVEMBER 1949

CONODONTS FROM THE LATE MISSISSIPPIAN PELLA BEDS OF SOUTH-CENTRAL IOWA

WALTER YOUNGQUIST AND A. K. MILLER
University of Idaho and State University of Iowa

ABSTRACT—Conodonts appear to be relatively rare in middle and upper Mississippian rocks and only a few specimens have been described from beds of that general age. A small assemblage has been secured from the type area of the Pella beds in south-central Iowa. The fauna contains representatives of six genera, *Cavusgnathus*, *Gnathodus*, *Ligonodina*, *Lonchodina?*, *Prioniodus*, and *Spathognathodus*. Six new species are established for some of the specimens. *Cavusgnathus* is the dominant generic element and comprises about half of the collection. *Ligonodina* and *Prioniodus* are also common, but the other genera are comparatively rare. These conodonts can best be compared with those known from the Caney shale of Oklahoma.

CONODONTS of middle and upper Mississippian age are scarce and comparatively few specimens have been noted or described in the literature. Furthermore, the references are scattered and consist in some cases of only a brief comment or two. Although the fauna under consideration is, by Devonian or lower Mississippian standards (both notable times of conodont abundance) rather sparse, it is nevertheless one of the larger conodont assemblages known from the later Mississippian.

Pander, the founder of conodont study, was the first (1856) to describe conodonts of possible middle or upper Mississippian age, but the exact horizon or horizons of the occurrences are uncertain. In 1900, Hinde described a small number of conodonts obtained from rocks of various ages and at several localities in the "Carboniferous limestone" of western Scotland. Roundy (1926) illustrated and described a few conodonts from the Barnett shale of central Texas—strata which carry the goniatite genera *Eumorphoceras*, *Goniatites*, *Girtyoceras*, and others which date the beds as about Meramec in age. A paper by Hermann Schmidt in 1934 called attention to the presence of conodonts in the Lower Namurian of Westphalia in the zone of *Eumorphoceras bisulcatum*. Schmidt did not treat the conodonts in detail and as individual specimens but regarded them as forming "assemblages"—that is, several different genera and species of conodonts were presumed to have been derived from a single organism. Each of these "assemblages" was named and Schmidt related them to fishes. Later the same year, Scott, writing on the possible zoological relationships of conodonts, illustrated specimens from the Heath formation (late Mississippian) of Montana. He, like Schmidt, treated the conodonts as "assemblages," and, incidentally, concluded that they were probably annelid remains. Relatively the most extensive treatment of late Mississippian conodonts has been by Branson and Mehl. In 1941 they stated that the Caney shale of Oklahoma (p. 167) "seems to contain conodonts in fair abundance in one or more zones," and they described and illustrated about 40 specimens. In this same paper Branson and Mehl indicate (p. 168) that they also had some conodonts from the Pitkin limestone of the same general region; four of these Pitkin conodonts were later illustrated and described by Branson and Mehl (1941b) as syntypes of a single species of *Spathognathodus*. Also in 1941, E. B. Branson and C. C. Branson (p. 131) in a discussion of the stratigraphy of the Wind River Mountains of western Wyoming noted that a "conodont fauna was recently discovered [in the *Sacajawea* formation] and is being studied." These authors apparently regarded the Sacajawea as either of Chester age or slightly older. What appear to be the youngest Mississippian conodonts so far described are those secured by C. L. Cooper (1947) from upper Kinkaid beds at the top of the Chester in southwestern Illinois. About a dozen conodonts were illustrated and described in a paper dealing

with the micro-fauna (largely ostracodes and Foraminifera) of these beds. These several papers constitute the literature of late Mississippian conodonts to date. For the sake of completeness, the small fauna of conodonts described from the Keokuk (Osage) by Branson and Mehl (1941a) should perhaps be mentioned, but that assemblage is from beds which are somewhat older than the others just considered and which belong to the lower part of the Middle Mississippian.

The conodonts of the present report do not constitute a very large collection—only some 220 specimens have been available for study and most of these are fragmentary. All the specimens were collected by Mr. C. B. Campbell of Knoxville, Iowa, and he got them from an exposure of shale in the type area of the Pella beds in the quarries about four miles south of Pella, Iowa, along the north bank of the Des Moines River. At this place the St. Louis limestone has been quarried, and that formation and the overlying Pella strata are well exposed. The Pella beds are chiefly light gray shales which carry an abundant and very beautifully preserved macro-fauna consisting of brachiopods, gastropods, corals, and a few blastoids and cephalopods. The micro-fossils include a large bryozoan fauna, numerous ostracodes, a few Foraminifera, and a very few conodonts.

This assemblage of conodonts includes six genera, *Cavusgnathus*, *Gnathodus*, *Ligodina*, *Lonchodina?*, *Prioniodus*, and *Spathognathodus*. Six new species are established for some of the specimens. About half of the total number of conodonts in the collection are referable to *Cavusgnathus*. *Ligonodina* and *Prioniodus* are fairly abundant whereas the other genera, particularly *Gnathodus* (represented by only one specimen), are rather rare. The genus *Hindeodella*, usually a very common element in conodont faunas of the middle and late Paleozoic, is noteworthy for its total absence in our collection. This fact has a striking near-parallel in the Caney fauna described by Branson and Mehl; those authors state that one (1941, p. 169) "of the surprising features of the fauna is the small number of hindeodellids."

The lack of any appreciable number of other late Mississippian conodont faunas which might be used for comparisons makes the correlation of the Pella beds on the basis of conodonts difficult. A fairly close relationship with the Caney shale is indicated, but this correlation may perhaps be more apparent than real inasmuch as the Caney conodont fauna is the only other late Mississippian assemblage of any size that has so far been illustrated and described. As has been pointed out by Branson and Mehl (1941, p. 168), the Caney fauna lacks completely such forms as *Doliognathus*, *Polygnathus*, *Pseudopolygnathus*, and related genera which are characteristic of parts of the Kinderhook, some of them also ranging well up into the Osage. Absent also are *Idiognathodus and Streptognathodus* which seem to appear early in the Pennsylvanian. *Gnathodus* is not a diagnostic genus for it ranges well down into the Mississippian and also extends up into the Pennsylvanian. Ellison (1946, fig. 1) has indicated that *Cavusgnathus* is confined to Chester and younger rocks. If so, the combination of that genus and *Gnathodus* (both found in the Caney and Pella beds) and the total absence of *Idiognathodus* and *Streptognathodus* would limit the Caney and Pella conodont faunas to a Chester age. However, the Caney shale carries the goniatite genera *Eumorphoceras* and *Goniatites*, and these two forms in direct association are generally believed to indicate a Meramec age for the containing strata (Weller, *et al.*, 1948, pp. 116–119). Therefore, the Caney fauna can probably be said to indicate that *Cavusgnathus* ranges down into the Meramec. In conclusion it can be said that the conodonts we are studying are indicative of either a Meramec or a Chester age for the Pella beds—present lack of published information on conodont faunas of this general age precludes a more nearly precise determination.

Acknowledgment is due Mr. C. B. Campbell of Knoxville, Iowa, whose careful field and microscopic examinations of the Paleozoic rocks in the vicinity of Knoxville have resulted in the discovery of many new conodont faunas including these Pella specimens. Dr. H. R. Downs generously gave of his time to aid in photographing the conodonts. All the illustrations are photographs which were retouched by Mr. Howard Webster of Iowa City. This report was made financially possible by the Graduate College of the

State University of Iowa, and the Department of Geology and Geography, University of Idaho. The type and figured specimens have been placed in the repository of the Geology Department at the State University of Iowa.

SYSTEMATIC PALEONTOLOGY

CAVUSGNATHUS REGULARIS Youngquist and Miller, n. sp.
Plate 101, figures 24, 25

Specimen stout; blade short, platform large and high. A deep groove occurs medianly the length of the platform's oral surface. Aboral margin of mid-portion of platform is flared laterally, chiefly on inner side. Escutcheon, except for a narrow central longitudinal groove, is wide and shallow. Blade consists of about five or six stout, laterally compressed denticles which are fused approximately three-fourths their length. These denticles are in a more or less regularly gradational series with the larger ones toward the posterior. The posterior two or three are approximately equal in size.

This species is distinguished from our *C. unicornis* by its somewhat shorter and more compact form and by the rather regular series of denticles composing the blade instead of a prominent posterior denticle.

The genus *Cavusgnathus* may occur in the Carboniferous of western Scotland for a similar specimen has been described and illustrated by Hinde (1900, p. 342, pl. 9, fig. 5) as "*Polygnathus navicula*." Superficially it somewhat resembles our *C. regularis* although the illustration precludes satisfactory comparisons. Hinde's specimen is stated to have come from the "Lower Limestones" of the Carboniferous limestone and this fact suggests that the specimen might possibly be referable to *Taphrognathus*, a genus which occurs somewhat lower in the Mississippian than does *Cavusgnathus* and may be ancestral to the latter.

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Types.—State Univ. Iowa, 4172 (holotype, fig. 24), and 4173 (paratype, fig. 25).

CAVUSGNATHUS UNICORNIS Youngquist and Miller, n. sp.
Plate 101, figures 18–23

Platform high, narrow, and deeply grooved orally. Both outer and inner parapets are crenulated along their oral margins. Outer parapet extends anteriorly to form a short, high blade which is a fourth or less the total length of the specimen. Blade composed of about five to seven closely appressed denticles which are more or less gradational in size with the exception of the posterior-most one, and increasing in magnitude from anterior to posterior. Posterior-most denticle is appreciably larger and higher than any of the other denticles of the blade and it stands out from the rest of the series. Remaining denticles fused nearly to their apices and compressed laterally. Aboral central portion of platform strongly flared laterally, more so on inner than on outer side, forming a flange-like structure. Entire specimen very gently bowed and arched.

The horn-like appearance of the posterior-most denticle is the most distinctive feature of our species and serves to distinguish it from *C. cristata* Branson and Mehl in the holotype of which there is no gradational series of denticles in the blade and one of the median rather than the posterior-most denticle is the most prominent. The fragmentary specimen figured by Cooper (1947, pl. 20, fig. 9) may be closer to our *C. unicornis* than to *C. cristata* to which it has been related. Of all the described representatives of *Cavusgnathus*, *C. arca* Sturgeon and Youngquist (1949, pl. 75, figs. 11, 12) from the Allegheny of Ohio appears superficially, at least, to be the closest to our late Mississippian form for it also has a large posterior denticle. However, the Allegheny species is considerably smaller, has a relatively longer blade and a relatively wider groove in the oral surface of the platform, and is much more arched than is *C. unicornis*

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Types.—State Univ. Iowa, 4174 (holotype figs. 18, 19), 4175 (paratype, fig. 20), 4176 (paratype, figs. 21, 22), and 4177 (paratype, fig. 23).

GNATHODUS LIRATUS Youngquist and Miller, n. sp.
Plate 101, figures 15–17

Only a single representative of the genus *Gnathodus* occurs in our collection. It has a platform which is considerably expanded

laterally on the outer side (orientation based on the slight curvature of the blade and carina), but only slightly expanded on the inner side. The outer oral zone of the platform is relatively flat and is ornamented by irregularly spaced nodes. The inner side of the platform is curved orad forming a narrow groove or furrow between the margin of the platform and the carina. The carina dominates the oral surface of the platform and is high, stout, and extends posteriorly well beyond the platform proper. Anteriorly, it grades into the blade. The carina is formed from a series of closely fused and somewhat compressed denticles which are only very slightly discrete distally, giving a crenulate appearance to the carina. Aborally, the platform is broadly excavated (see fig. 16).

The blade of our holotype is incomplete anteriorly, but presumably it was very much like that structure in *G. pustulosus* Branson and Mehl (1941, pl. 5, fig. 35), from the Caney shale, which it somewhat resembles. Our form differs, however, in having the inner oral margin of the platform sharply curved orad forming a narrow furrow between the edge of the platform and the carina; also the latter structure is stouter than in *G. pustulosus*.

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Holotype.—State Univ. Iowa, 4178.

LIGONODINA sp.
Plate 101, figures 11–13

Among the more than 200 conodonts in our collection, *Ligonodina* is represented by about 30 individuals, all of which are fragmentary. We are illustrating by inner lateral views the three which are the most nearly complete; all 30 of the specimens are quite similar. The cusp is long, rounded (although slightly compressed laterally), and it curves rather strongly posteriad. The posterior bar appears to have been rather short and preserved portions of it bear several small rounded denticles which are discrete to the places of insertion into the bar. The bar is flattened laterally and is slightly excavated aborally. The anticusp is deflected inward and in the specimen which retains relatively the largest portion of this structure (fig. 11), it is also distally deflected aborad and is denticulate. The preserved portions of these specimens indicate that they are probably closely related to or may be conspecific with *L. tenuis* Branson and Mehl of the Caney shale of Oklahoma.

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Figured specimens.—State Univ. Iowa, 4179 (fig. 11), 4180 (fig. 12), and 4181 (fig. 13).

LONCHODINA? spp.
Plate 101, figures 7, 8

A few specimens in our collection are typically illustrated by two which are shown by our figures 7 (outer lateral view) and 8 (inner lateral view). Although too fragmentary to permit identification with cer-

EXPLANATION OF PLATE 101

All specimens are from the type area of the Pella beds, about 4 miles south of Pella, Iowa. The illustrations are ×40.

FIGS. *1–3*—*Spathognathodus cristula* Youngquist and Miller, n. sp. The holotype (fig. *1*) and two paratypes. (p. 621)

4—*Spathognathodus spiculus* Youngquist and Miller, n. sp. Outer lateral view of the holotype. (p. 622)

5—*Spathognathodus bidens* Youngquist and Miller, n. sp. Outer lateral view of the holotype. (p. 621)

6—*Spathognathodus pellaensis* Youngquist and Miller, n. sp. Outer lateral view of the holotype. (p. 622)

7, 8—*Lonchodina?* spp. Two specimens. (p. 620)

9, 10—*Prioniodus* spp. Outer lateral views. See also fig. *14*. (p. 621)

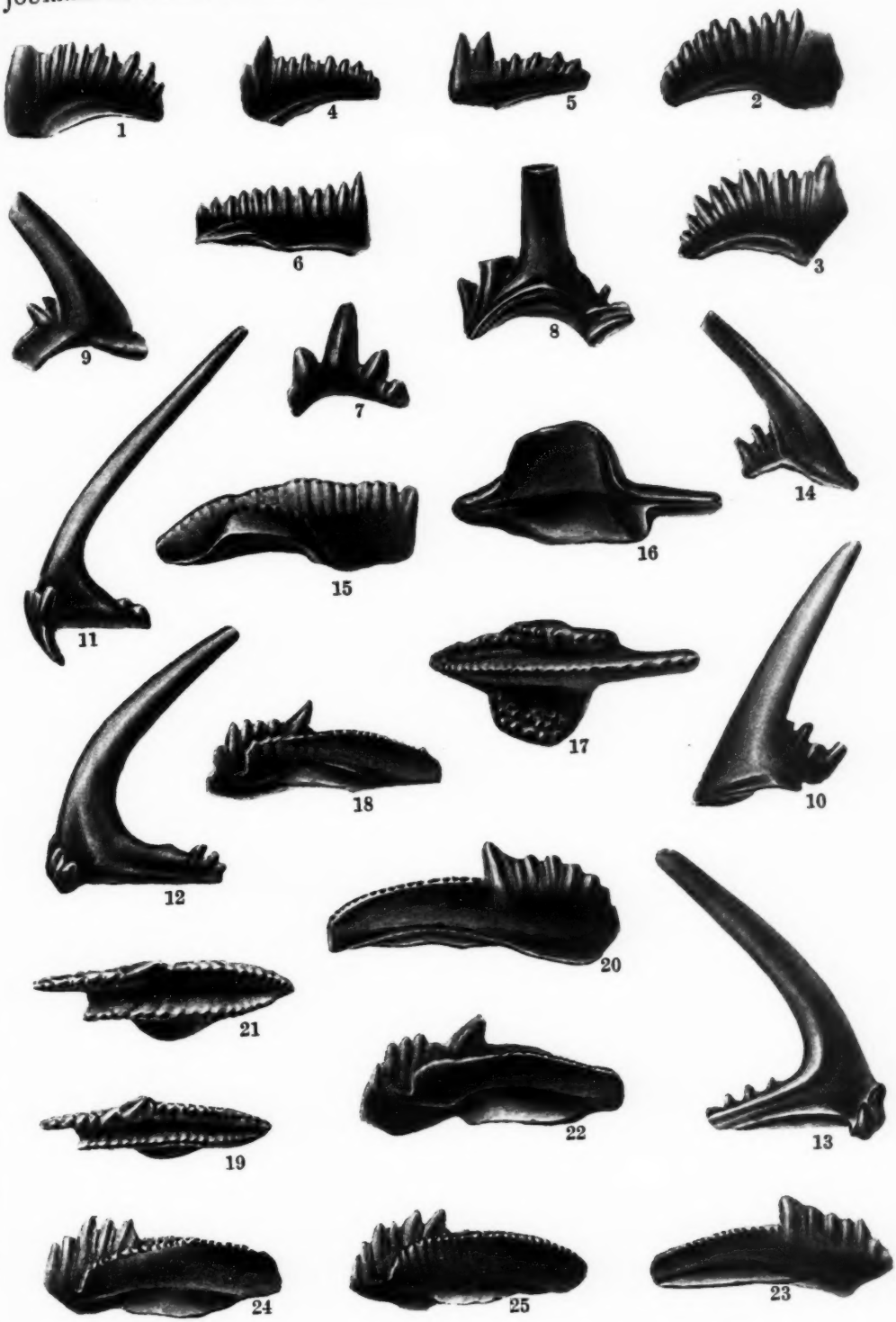
11–13—*Ligonodina* sp. Inner lateral views of three individuals. (p. 620)

14—*Prioniodus* sp. Inner lateral view. See also figs. *9, 10*. (p. 621)

15–17—*Gnathodus liratus* Youngquist and Miller, n. sp. The holotype. (p. 619)

18–23—*Cavusgnathus unicornis* Youngquist and Miller, n. sp. The holotype, figs. *18, 19*. Outer lateral view of a large individual, fig. *20*. Oral and lateral views of a paratype, figs. *21, 22*. Outer lateral view of a paratype, fig. *23*. (p. 619)

24, 25—*Cavusgnathus regularis* Youngquist and Miller, n. sp. The holotype (fig. *24*) and paratype. (p. 619)



Youngquist and Miller, Late Mississippian Conodonts

tainty, they are reminiscent of the general form of *Lonchodina* with the exception, however, that our specimens are bowed inward rather than outward. The bar limbs appear to be subequal in length and the denticles are discrete, just as in the holotype of *L. typicalis* Ulrich and Bassler, the genotype. Similar elements in the Caney conodont fauna have been noted by Branson and Mehl and referred to *Lonchodina* (1941, p. 171). These authors describe the specimens in part as "more or less doubly curved bars with long discrete denticles, none sufficiently complete for positive identification. . . . The small number of such fragmentary specimens indicates that this genus is of minor importance in the [Caney] fauna."

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Figured specimens.—State Univ. Iowa, 4182 (fig. 7), and 4183 (fig. 8).

PRIONIODUS spp.
Plate 101, figures 9, 10, 14

Representatives of the genus *Prioniodus* are fairly common in our collection but none of them are sufficiently complete to serve satisfactorily as holotypes. Nevertheless, it seems clear that more than one species is represented and all may well be new.

The individual illustrated by figure 9 has a cusp which is rounded in cross section, more narrowly so along the anterior and posterior margins than laterally. The aboral margins of the bar and of the cusp are expanded laterally—the cusp also has an anterior-aborad flange-like extension. Entire specimen moderately arched. The denticles on the bar are rounded and discrete to their base. Figure 10 represents a somewhat similar individual (from an inner view) in which the denticles are more closely appressed. Figure 10 also illustrates, as is the case of the previous specimen though not shown, the lateral expansion of the inner aboral margin of the cusp. Figure 14 shows a specimen which has a markedly compressed cusp which is attenuate in an aboral-anterior direction, forming a short anticusp. Both the cusp and denticles incline moderately posteriad; the denticles are rounded and discrete and the bar is compressed. *Prioniodus varians* Branson and Mehl of the Caney shale has a laterally compressed bar but has a cusp which inclines anteriorly and denticles which are closely appressed.

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Figured specimens.—State Univ. Iowa, 4184 (fig. 9), 4185 (fig. 10), and 4186 (fig. 14).

SPATHOGNATHODUS BIDENS Youngquist and Miller, n. sp.
Plate 101, figure 5

This species is particularly characterized by the presence of two large denticles approximately equal in size, in the position of the cusp. There are no denticles anterior to this place; posteriorly there are about eight low, stout denticles. The blade is small but relatively stout, although strongly compressed laterally. The entire specimen is gently bowed and the posterior portion of the blade is slightly arched. The base of the blade along its median portion bears narrow lateral flanges which encompass the broad but shallow escutcheon.

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Holotype.—State Univ. Iowa, 4187.

SPATHOGNATHODUS CRISTULA Youngquist and Miller, n. sp.
Plate 101, figures 1–3

Blade short, moderately arched, much compressed, composed of about 10 denticles fused nearly to their apices, and very slightly bowed. Base of blade broadly flared reaching maximum lateral extent about mid-length on the blade. Cusp equal in width to three or four of the denticles; no denticles appear to be present anterior of cusp.

Superficially at least this species is perhaps closest to *S. minutus* Ellison which, however, is known from younger rocks. Our form can be distinguished by the fewer number of denticles posterior to the cusp, and particularly by the absence of denticles anterior of that structure. *S. minutus* is stated to bear three short denticles anterior to the cusp.

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Types.—State Univ. Iowa, 4188 (holotype fig. 1), 4189 (paratype, fig. 2), and 4190 (paratype, fig. 3).

SPATHOGNATHODUS PELLAENSIS Youngquist and Miller, n. sp.
Plate 101, figure 5

The illustrated holotype of this species appears to be complete in every detail. It consists of approximately 11 denticles which are rather uniform in size, although gradually increasing somewhat in magnitude toward the anterior. The cusp is only slightly larger than some of the larger denticles. No denticles are present anterior of the cusp. The anterior portion of the blade in lateral profile is terminated by nearly a right angle. The flared aboral margins of the blade are confined to the posterior half of the specimen. The blade as a whole is relatively stout, and is only very gently bowed and arched.

S. commutatus Branson and Mehl from the Pitkin limestone and Caney shale of Oklahoma is somewhat similar to our *S. pellaensis*. However, our form can be distinguished by the considerably fewer number of denticles which are not so closely appressed as in the former species. Also, in a plesiotype of *S. commutatus* identified by Branson and Mehl (1941, pl. 5, fig. 19) the cusp is not terminal but is succeeded anteriorly by two additional denticles. This feature is also somewhat elucidated by one of the syntypes (Branson and Mehl, 1941b, pl. 19, fig. 3). In our *S. pellaensis* the cusp is terminal. What appears from the rough illustration to be a rather closely related form to our species, however, is the particular specimen described by Hinde (1900, p. 343, pl. 9, fig. 10) as *Polygnathus scitulus* from the "Upper Limestones" of the Carboniferous limestone of western Scotland.

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Holotype.—State Univ. Iowa, 4191.

SPATHOGNATHODUS SPICULUS Youngquist and Miller, n. sp.
Plate 101, figure 4

Blade gently arched in posterior two-thirds; entire blade slightly bowed and composed of about 10 laterally compressed denticles posterior to the cusp which are sheathed by blade material nearly to their apices. These denticles are not closely appressed but retain their individuality well down into the blade. A relatively high, sharp, narrow cusp is present and immediately adjacent to it anteriorly there is a single denticle. The base of the blade is considerably flared laterally, except in its anterior-most portion and the escutcheon is broad and shallow.

Occurrence.—Pella beds 4 mi. south of Pella, Iowa.

Holotype.—State Univ. Iowa, 4192.

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PEDIOCERAS, A SYNONYM OF *CRIOCERAS* (*PSEUDOCRIOCERAS*)

KEITH A. YENNE
Bogotá, Colombia

THIS note is written in an attempt to clarify some of the confusion which exists concerning the ammonite genus, *Pedioceras*. The synonymy of *Pedioceras* and *Crioceras* (*Pseudocrioceras*) has been previously suggested by Dr. Royo y Gomez (1945) in his paper on Barremian fossils of Colombia, but because this paper was written in Spanish and published in Colombia it may not have come to the attention of many English-speaking geologists and paleontologists working on the lower Cretaceous. Dr. Royo's observations have been verified by the writer, and as further proof of the synonymy, the suture line of *Pedioceras* is figured here for the first time.

The genus *Pedioceras* was erected by Gerhardt in 1897. Three species were recognized: *P. caquesensis* (Karsten), *P. ubaquensis* (Karsten), and *P. cundinamarcae* Gerhardt, but none of the three was designated as the genotype. All three species came from Colombia and Gerhardt (1897) gave their age as Neocomian. In later studies by Hyatt (1903), Roman (1938), and Imlay (1944), *Pedioceras* was described as an Aptian ammonite.

Dr. Royo (1945) states that in Colombia *Pedioceras* is associated with *Pulchellia* and *Nicklesia*. The writer, likewise, has found *Pedioceras* only in strata which contain *Pulchellia* and *Nicklesia*. At least in Colombia therefore, the genus is probably limited to the lower Barremian.

Also associated with *Pedioceras* are fragments of a large uncoiled ammonite which belongs to the subgenus *Pseudocrioceras* Spath. According to Royo (1945) *Crioceras* (*Pseudocrioceras*) is exceedingly variable and the three species of *Pedioceras* are actually variations of one species of young *Crioceras* (*Pseudocrioceras*). The writer agrees with this but in addition believes the variations are attributable to growth stages of the species. Thus the early neanic stage of *Crioceras* (*Pseudocrioceras*) *ubaquense* (Karsten), (the name proposed by Dr. Royo in 1945 for all the forms of *Pedioceras*), has well-developed slightly sinuous ribs which are terminated near the ventral area by two small nodes. The venter is smooth. There are no nodes in the region of the umbilicus. The whorls are quadrate and moderately involute. *Crioceras* (*Pseudocrioceras*) *ubaquense* at this stage of development were called *Pedioceras ubaquensis* by Gerhardt. In the later neanic stages (Gerhardt's *Pedioceras caquesensis*), the ribs continue across the venter, although they are subdued in the ventral region. *Pedioceras cundinamarcae* Gerhardt represents the ephebic stage of *Crioceras* (*Pseudocrioceras*) *ubaquense*. The ribs have become more erratic, and major and minor ribs are evident. Ventral nodes have become faint or have disappeared on the weaker ribs but are more prominent than before on the stronger ribs. For the first time there is a slight development of a node on some of the major ribs in the area of the umbilical shoulder. The gerontic stage has the form of a true *Crioceras* (*Pseudocrioceras*). Major ribs bearing three prominent nodes are separated by a variable number of minor ribs without nodes. The ammonite is no longer involute and the whorls are oval in shape rather than quadrate.

The suture line of a young *Pedioceras* found by the writer near Chipatá, Departmento de Santander, is further evidence of the synonymy. The genotype of Spath's subgenus, *Pseudocrioceras*, is *Crioceras abichi* (Bacevic and Simonovic). Its suture line is unknown. However, Kilian (1913) states that *Crioceras abichi* belongs to his "Gruppe" of *Ancyloceras matheronianum* d'Orbigny. The similarity of the suture lines of *Pedioceras* and *A. matheronianum* is demonstrated on plate 102. The suture line of *A. matheronianum* is more complex, but the main points of ramification are the same. A difference in the complexity of the suture line is to be expected when the young stage of an ammonite genus is compared with the old stage of the same genus.

In conclusion it must be pointed out that

one complete specimen of *Crioceras* (*Pseudocrioceras*) *ubaquense* showing all the growth stages has not been found. In addition, the amount of literature and type specimens available to the writer is limited. Nevertheless, it is believed that sufficient evidence exists to prove that the three species of *Pedioceras* are growth stages of *Crioceras* (*Pseudocrioceras*) *ubaquense* (Karsten).

I am greatly indebted to Dr. Royo for permission to examine specimens belonging to the Colombian Geological Survey and to J. Wyatt Durham of the University of California with whom I corresponded concerning the suture line of *Pedioceras*. However, I do not intend to imply that either paleontologist necessarily agrees with my conclusions. I also wish to thank the Tropical Oil Company, Bogotá, Colombia, for permission to publish this paper.

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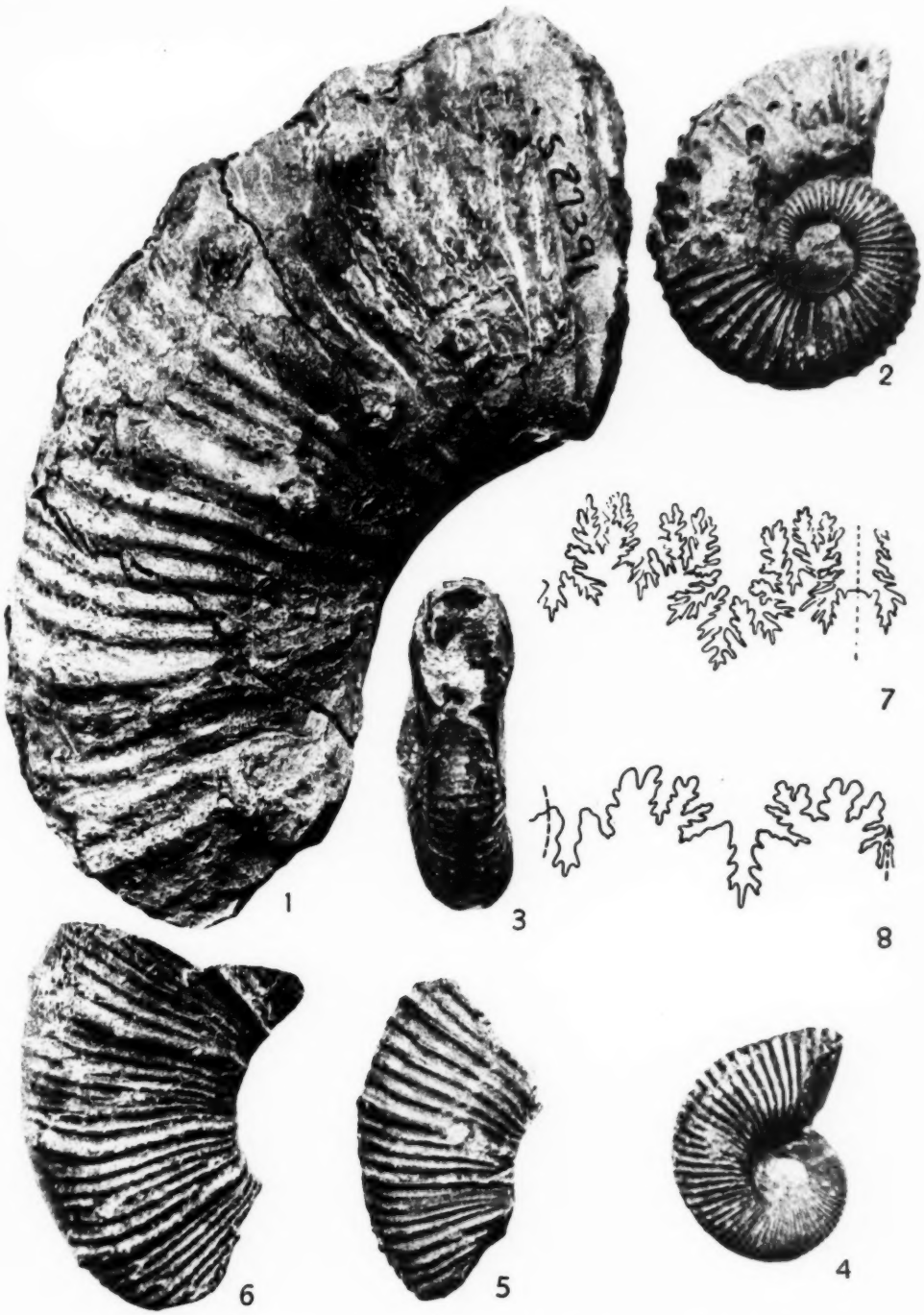
EXPLANATION OF PLATE 102

FIGS. *1–6*—*Crioceras* (*Pseudocrioceras*) *ubaquense* (Karsten). *1*, Fragment demonstrating gerontic stage. Specimen No. 2-S27391 from roadcut three kilometers southeast of Villeta along Villeta-Bogotá road. *2*, *3*, two views of specimen No. 7-S43011, late neanic stage, slightly crushed but showing development of ribs and the oval-shaped cross section of later whorl. *4*, specimen No. 6-S43011, early neanic stage. *5*, specimen No. 8-S43011, early ephebic stage. *6*, specimen No. 5-S43011, ephebic stage. All specimens natural size; all except fig. *1* from locality 2 kilometers northeast of Chipatá. (p. 623)

7—Suture line of *Ancyloceras matheronianum* d'Orbigny (after Roman, 1938). (p. 623)

8—Suture line of *Crioceras* (*Pseudocrioceras*) *ubaquense* (Karsten). Camera lucida drawing of suture line of specimen No. 6-S43011 (fig. *4*). (p. 623)

All specimens in the type collection of the Tropical Oil Company, Bogotá, Colombia.



Yenne, Crioceras (Pseudocrioceras) ubaquense Karsten)

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LITHOSTROTION FROM NORTHEAST BRITISH COLUMBIA AND ITS BEARING ON THE GENOMORPH CONCEPT

D. J. McLAREN AND P. K. SUTHERLAND
Geological Survey of Canada, Ottawa, and Phillips Petroleum Company, Bartlesville, Oklahoma

ABSTRACT—The variation between the corallites in a fragment of a massive Mississippian coral from northeast British Columbia embraces structures which are typically developed in *Lithostrotion*, *Lithostrotionella* and *Thysanophyllum*. The affinities of these and related forms are discussed. It is considered that *Lithostrotionella* and *Thysanophyllum* are genomorphs of *Lithostrotion* but that *Thysanophyllum* is a polyphyletic form which may have arisen from several different lineages.

INTRODUCTION

WHILE engaged in stratigraphical reconnaissance for the Phillips Petroleum Company in northeast British Columbia during the summer of 1948, one of the authors (P. K. S.) collected a large fragment from a massive coral of the *Lithostrotion* type. The coral was in place in an 18 inch bed of finely crystalline grey limestone which occurs in an irregularly interbedded series of limestone and grey chert within 4 ft. of the top of the Mississippian section. The outcrop is located near the headwaters of Bull Creek, a tributary of the Prophet River, at a point some 6 miles south of the Muskwa River and approximately 26 miles west of Mile 202 on the Alaska Highway.

An examination of thin sections made from the fragment disclosed that there were present in this one corallum three types of coral structure which had hitherto been referred to distinct genera. These structures are developed in the genera *Lithostrotion*, *Lithostrotionella*, and *Thysanophyllum*.

In this paper these "genera" are discussed together with others which have been considered related to them at one time or another. It is believed that the Bull Creek specimen throws fresh light on their affinities and certain tentative conclusions are reached concerning them. The specimen is described, but no specific name is assigned to it as it is considered that the material is insufficient to justify a new name.

THE GENOMORPH CONCEPT

It has become increasingly clear since the beginning of this century that the classical ideas on taxonomy must, at least as far as corals are concerned, be highly modified. Vaughan (1905, p. 277), in a discussion on *Lithostrotion* remarked that the coral species recognized by Edwards and Haime (1852) represent a purely artificial classification. He listed the important structural modifications which may affect various species of *Lithostrotion* and suggested that these changes are not of systematic importance. For instance, he recognized that *Diphyphyllum lateseptatum* McCoy and *Lithostrotion martini* Edwards and Haime have specific identity.

Smith (1916, p. 237) drew attention to the fact that the term "species"as applied to Paleozoic corals may not be used in the zoological sense, but is in all probability merely a convenient term to distinguish similarly constructed exoskeletons of animals whose genetic make-up is quite unknown. He cited Matthai's research on recent Madreporaria to support this contention (1914). Lang carried this idea further in his concept of trends. In his papers (1923a, 1923b, 1939) he traced evolution in the Rugosa as a series of trends one or more of which is followed by every lineage. He considered a genus to be a convenient grouping of similar forms which have reached the same stage of development in independent lineages (Lang, Smith & Thomas, 1940, p. 5).

Smith and Lang (1930, p. 179) introduced the idea of a genomorph complementary to the trend concept. A genomorph does not constitute a true genus but is an expression of a trend "which some external or internal

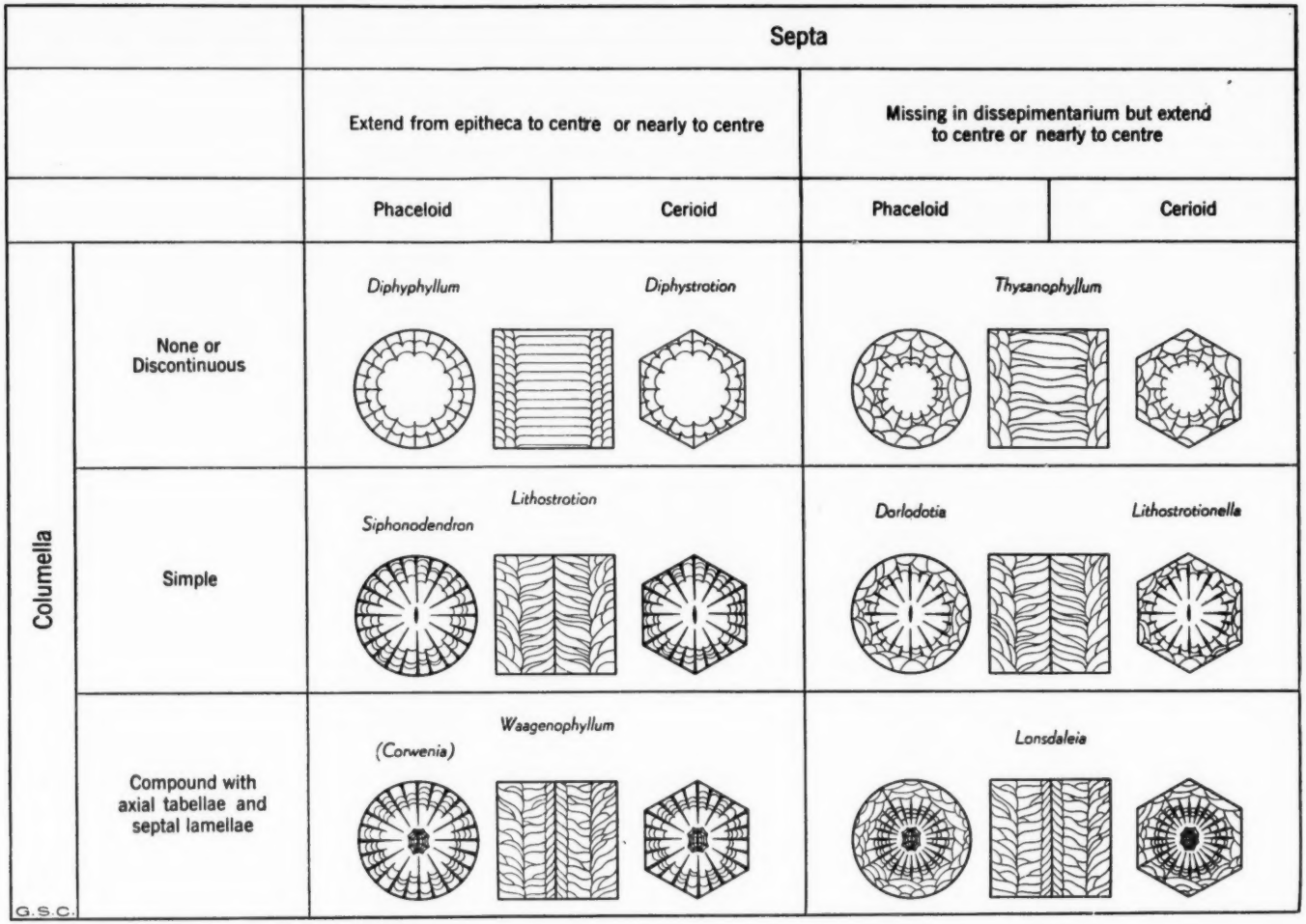


FIG. 1—Characteristics of *Lithostrotion* and other genera.

stimulus has provoked to rapid development in a colony or in certain individuals of a colony." They suggested that the individual genomorph is the forerunner of an evolution which may take place in closely or distantly related stocks and may give rise to new generic forms. They described two genomorphs of *Lithostrotion* in which the columella is lacking, the septa shortened and the tabulae flat or distally arched. A phaceloid *Lithostrotion* in which this trend is dominant was termed genomorph {*Diphyphyllum* Lonsdale}; a cerioid *Lithostrotion* with the same trend became genomorph {*Diphystrotion* Smith & Lang}. The most important point in their discussion is that a genomorph and a normal *Lithostrotion* can occur in the same corallum.[1]

Hill (1934, p. 83), also in a discussion on the genus *Lithostrotion*, listed the possible developmental trends which this form might follow and noted that, except where they are mutually exclusive, all the various trends might be found in the same individual. It is more usual, however, for only one to be pronounced and such individuals may be united in "genomorphic groups."

The concept of the genomorph appears to have been accepted on this continent but there has been no standardized procedure for indicating when a generic name is being used in this sense. For instance, Sanford (1939, p. 405) merely listed genomorphs together with genera and sub-genera; Merriam (1942, p. 380) interposed the word genomorph between the generic and genomorphic name; Kelly (1942, p. 358) recognized that *Diphyphyllum* is a genomorph but made no attempt to indicate this when writing the name of a species in full. Smith and Lang (1930, p. 180) originally suggested putting the genomorph and species name in braces behind the genus from which it was developed, e.g. *Lithostrotion* sp. {*Diphyphyllum concinnum* (Lonsdale)}. This has not had general acceptance and it is admittedly somewhat inconvenient. Smith has, however, modified the original system himself (1945, p. 22). He places the genomorphic name, enclosed in square brackets, behind the genus in the position of a subgeneric name, e.g. *Disphyllum* [*Phacellophyllum*] *caespitosum* (Goldfuss). He does not appear to suggest that a genomorphic name should always be placed in square brackets but rather that it may be used as a normal generic name in discussions. When assigning a species to its correct genus, however, the genus and the genomorph should be differentiated. In other words, in employing a genomorphic name the usage is analogous to that of a subgeneric name. It is suggested that this practice be adopted in dealing with a taxonomic problem which has no parallel in neontology and can thus have no counterpart in normal zoological nomenclature.

Although the genomorph concept thus undermines the zoological reality of many of the rugose coral genera, nevertheless the use of existing names must continue since they are convenient for describing the various forms and are useful in stratigraphy.

[1] It is of interest to note that Smith (1945) has recently recognized genomorphs of several genera of Devonian corals.

FIG. 1—Characteristics of *Lithostrotion* and other genera.

NOTES ON GENERA

It is of value to summarize the main points of similarity and difference between the various genera in any way connected with the present study and which have at one time or another been considered related to *Lithostrotion*. This is most conveniently illustrated by figure 1, but it must be understood that no genetic significance is to be attached to the grouping, and that this is merely a way of showing morphological differences. The drawings on figure 1 are entirely diagrammatic but will serve to emphasize the main similarities and differences of the genera.

This figure summarizes two of the principal changes possible in the *Lithostrotion* structure; those affecting the septa and those affecting the columella. In some genera the septa do not reach the epitheca but are separated from it by a zone of dissepimental tissue. At this stage the septa may either reach the centre of the corallite or extend only a part of the way into the tabularium. In other genera the columella structure departs from the simple styliform type and may be reinforced by septal lamellae and axial tabellae to form a compound central column. On the other hand it may be reduced to a short discontinuous process

resting on successive tabulae, or it may be absent altogether.

Genus LITHOSTROTION Fleming, 1828

Phaceloid and cerioid rugose corals, which have, typically, a columella, long major septa, and large tent-shaped tabulae, usually supplemented at the theca by smaller and nearly horizontal tabulae. Dissepiments are well developed in the large species, but absent in the very small forms. Gemmation is non-parricidal. Diphymorphs of *Lithostrotion* have no columella, short septa, flat or distally arched tabulae, and in the phaceloid forms, parricidal gemmation (Smith and Lang, 1930, p. 178).

Fleming's original description of *Lithostrotion striatum*, the genolectotype standardized by the International Commission of Zoological Nomenclature, Opinion 117, notes that "the rays of the stars unite with a small solid central axis." In the interpretation of the genus various authors are unanimous in accepting as *Lithostrotion* forms in which the septa fall short of the columella as well as forms in which the major septa merge with it. This was noted by Vaughan (1905, p. 277): "the septa extend inwards, for a greater or less distance, along the upper faces of the tabulae."

Lithostrotion is known from the Lower Carboniferous[2] of North America, Eurasia and Australia, the Upper Carboniferous of Russia and the Permian of China.

Genus SIPHONODENDRON McCoy, 1849

Lang, Smith and Thomas (1940, p. 119) pointed out that this genus is identical with small phaceloid *Lithostrotion* species and considered it a synonym unless phaceloid and cerioid forms are separated. The genus has not received general recognition and it certainly seems inadvisable to separate two genera on a single progressive character such as the form of the corallum.

Genus LITHOSTROTION [DIPHYSTROTION] Smith and Lang, 1930

Genus LITHOSTROTION [DIPHYPHYLLUM] Lonsdale, 1845

Respectively the cerioid and phaceloid diphymorphs of *Lithostrotion*. *Diphyphyllum* appears to be generally accepted as a genomorph. *Diphystrotion* has been questioned, however, by Hill (1940, p. 161) who considered it a synonym of *Thysanophyllum*.

Following the line of reasoning applied to *Siphonodendron* it is not clear why two genomorphs were named for this modification of the lithostrotion form, particularly as Smith and Lang mention the possibility that both genomorphs may give rise to cerioid and phaceloid forms of *Thysanophyllum* respectively.

Diphyphyllum is known from the Lower Carboniferous (Viséan) of Britain, Eurasia and Australia, possibly from the Upper Carboniferous of Russia and the Permian of Japan and China. It is unknown in America although various Silurian and Devonian species have been incorrectly assigned to the genus on this continent. *Diphystrotion*, if accepted, is only known from the Lower Carboniferous (Viséan) of Europe.

Genus LITHOSTROTION [THYSANOPHYLLUM] Nicholson and Thomson, 1876

Phaceloid and cerioid forms without columella. Septa separated from epitheca by a zone of dissepiments. Tabulae well spaced and almost flat.

This form is described fully by Thomson (1880, p. 256). Garwood (1912, p. 262) remarked on the great variation in the size of the corallites and on the fact that in young individuals there is a tendency for some of the septa to extend across the outer zone of vesicular tissue, i.e. the dissepimentarium. Hill (1940, p. 161) suggested that the genus might be polyphyletic and considered that possibly *Lithostrotionella*, as well as *Diphystrotion*, is a synonym of *Thysanophyllum*.

Thysanophyllum is known from the Lower Carboniferous of Eurasia, from the Upper Carboniferous of Russia, and the Permian of Russia and China.

[2] The terms Lower and Upper Carboniferous are used rather than Mississippian and Pennsylvanian in order to avoid confusion between the range of genera in America and Eurasia. The Mississippian includes the Dinantian and also part of the Upper Carboniferous Namurian (approximately zones E and H) of Europe. Lower Carboniferous is thus used in a more restricted sense than Mississippian.

Genus LITHOSTROTION [LITHOSTROTIONELLA] Yabe and Hayasaka, 1915

A cerioid form in which the septa are separated from the epitheca by a zone of dissepiments. Tabulae and columella identical with *Lithostrotion*.

This form was described originally as a subgenus of *Lithostrotion*, but subsequent authors, including Hayasaka (1936), have raised it to generic rank. It seems to have received general acceptance except by Hill (1940, p. 161). In an earlier paper (1934, p. 82) she suggested that *Lithostrotionella* might be a genomorph of *Lithostrotion* which had followed a lonsdaleoid trend. The danger of confusing this genus with *Lonsdaleia* seems very great and it is important to note that the columella in *Lithostrotionella* is a simple median plate not combined with septal lamellae or axial tabellae. (Hayasaka, 1936, p. 51).

Yabe and Hayasaka described the form of the corallum as being "composite, massive, composed of prismatic corallites." Later writers also appear to have accepted the genus as applying to cerioid corals only.

Lithostrotionella is known from the Lower Carboniferous of Eurasia, North America and Australia, from the Upper Carboniferous of Russia and the Permian of China and North America.

Genus DORLODOTIA Salée, 1920

This genus appears to be identical in internal structure with *Lithostrotionella* and it may well be a phaceloid form of that genomorph. It has been described from the Viséan of Belgium and is not widely represented. Hill (1940), however, considered three species of *Thysanophyllum* from China, described by Yü (1933, p. 41), to be members of this genus. It may represent a separate development, or successive developments, from phaceloid *Lithostrotion* species.

Genus WAAGENOPHYLLUM Hayasaka, 1924

Phaceloid and cerioid forms with a clisiophylloid axial column. Septa reach the epitheca which is thickened into a narrow stereozone; dissepimentarium wide, tabulae sometimes suppressed.

Yabe and Hayasaka (1915, p. 96) defined this genus under the name *Waagenella* (preoccupied) and implied a relationship with *Lithostrotion*. Huang (1932, p. 43) and Smith (1935, p. 35) considered it allied to *Lonsdaelia*, which seems a much more reasonable supposition.

Corwenia Smith and Ryder, 1926, a similar form conveniently considered here, is best described as being a phaceloid coral with the form of a small *Dibunophyllum*. Smith (1935, p. 34) considered that the homeomorphy was probably due to parallel evolution. He summarized the differences between *Corwenia* and *Waagenophyllum* in that the former has a wider tabulate zone, a more loosely formed central column and smaller dissepiments than the latter.

Waagenophyllum appears to be exclusively Permian from Asia and North America, although Hayasaka (1924, p. 23) has suggested that one of his species might be from the Lower Carboniferous of Japan. *Corwenia* is from the Lower Carboniferous of Europe and has been reported from the Upper Carboniferous and Permian of Asia. The Permian forms have been claimed to be *Waagenophyllum* by Smith (1935, p. 34) and Hill (1939, p. 100), whereas Moore and Jeffords (1941, p. 96) considered that they belong to their new genus *Heritschia*.

Genus LONSDALEIA M'Coy, 1849

Phaceloid and cerioid forms with a compound axial column composed of a median plate, septal lamellae and tabellae. Septa separated from epitheca by a zone of dissepiments. Tabulae inclined.

Smith (1916) described this genus in full, including its morphology and ontogeny together with views on its phylogeny. The genus seems to be generally accepted for both phaceloid and cerioid forms.

Lonsdaleia is known from the Lower Carboniferous of Eurasia and North America and the Upper Carboniferous and Permian of Russia and China.

CLASSIFICATION AND AFFINITIES

All authorities are agreed that the difference between *Lonsdaleia* and *Lithostrotion* is of family rank. The lonsdaleioid central column is plainly a very much more complicated structure than the simple columella

of *Lithostrotion*, and although both may well be polyphyletic, it seems unlikely that the simple gave rise to the more complex. This is supported by the stratigraphical evidence, in that *Lonsdaelia* appears at the top of the Tournaisian in Europe, whereas *Lithostrotion* is not known below the Viséan.

Although it is not intended to suggest that the one developed from the other *Lonsdaleia* is probably correctly associated with *Waagenophyllum* in the same family. If this is so, there is some doubt as to which family to assign both forms. Hill (1938, p. 55) would put *Lonsdaleia* in a separate family, the Lonsdaleiidae, leaving *Waagenophyllum* in the Clisiophyllidae. *Corwenia* appears similar to *Waagenophyllum*, but this may be entirely due to homeomorphy and the same may be said for the similarity between *Corwenia* and *Dibunophyllum*.

Since all the genera in this discussion are defined, at least in part, on progressive characters, there seems no logical reason why the grouping into families should not follow similar principles. Rather than separate *Waagenophyllum* from *Lonsdaleia*, and rather than associate both with *Dibunophyllum*, it seems at least reasonable to include all the compound corals with a clisiophylloid axial structure in the same family until the true affinities of these forms are fully understood. This has the merit of not separating forms which have been considered by various authors to be related. It is thus suggested that *Waagenophyllum* and *Corwenia* be included in the family Lonsdaleiidae, as defined by Grabau (unpublished) and used by Huang (1932), but that the simple corals with clisiophylloid axial structures be removed from that family.

In dealing with the Lithostrotiontidae the associations are more clearly defined. Granting that the generic name *Lithostrotion* may be applied to phaceloid and ceroid forms, Smith and Lang have shown the relations of *Diphyphyllum* and *Diphystrotion* as genomorphs of the genus. The very nature of a genomorph makes it inevitable that different species of the same form are polyphyletic, but the name remains as a convenient descriptive term, and indeed it is usually impossible to say with which species of *Lithostrotion* a genomorphic species is associated.

Lithostrotionella has been considered by several authorities to be a development or even a genomorph of *Lithostrotion* and intermediate types occur in both genera. For instance the Australian species *Lithostrotion? columnare* Etheridge (1900, p. 11) shows remarkable variations between corallites in the same corallum; in some the septa have retreated from the epitheca and the dissepiments are well developed in the intervening area. Benson and Smith (1923, p. 169) noted this trend in other Australian *Lithostrotion* species. On the other hand, some *Lithostrotionella* species show a tendency for the septa to become united with the epitheca, e.g. *L. stylaxis* (Trautschold) as described by Dobroljubova (1935, p. 40) and in species described by Hayasaka (1936)

In the Bull Creek coral described below, typical *Lithostrotionella* corallites occur in the same corallum and in close proximity to corallites with a normal *Lithostrotion* form. *Lithostrotionella* in this instance is shown to be a true genomorph of *Lithostrotion* and it is considered highly probable that many of its species are also genomorphs.

Little is known of *Dorlodotia* which seems a rare form, but it is at least possible that it developed from a phaceloid *Lithostrotion*.

The affinities of *Thysanophyllum* are considerably more complex than those of the preceding genera. Carruthers has shown that *Lonsdaleia floriformis* Martin passes through a thysanophylloid stage in early life (in Garwood 1912, p. 563), and Smith (1916, p. 235) has demonstrated also that the neanic stage of *L. duplicata* (Martin) closely resembles *T. pseudovermiculare* (M'Coy). On this evidence, both authorities suggest that *Lonsdaleia* may have actually developed phylogenetically from *Thysanophyllum*. Hill (1940, p. 151), however, pointed out that the evidence was insufficient to decide that this had taken place. She maintained that there was an equal likelihood that the reverse could have occurred. On the other hand Smith and Lang (1930, p. 184) stated that *Diphystrotion* and *Diphyphyllum* "lead on to" a cerioid and phaceloid *Thysanophyllum* respectively, although the evidence for this is not clear. Finally, in the coral described below, typical *Thysanophyllum* corallites are associated

with *Lithostrotionella* and *Lithostrotion* corallites in one corallum. Thus *Thysanophyllum* seems a homeomorphic form which could be developed from or give rise to genera which are in different families and which have very different structures.

DIRECTION OF TRENDS

A question that naturally arises from the foregoing discussion is whether there is any evidence to show which of the various forms gave rise to the others. In other words, in which direction did the genomorphic trends operate?

With *Lonsdaleia* there seems some evidence to suggest that the genus developed from a thysanophylloid form. This evidence necessarily assumes that the ontogeny of *Lonsdaleia* recapitulated its phylogeny, but the principle of recapitulation is difficult to apply and its application appears in this instance to be without proof. If a thysanophylloid form is in any way associated with *Lonsdaleia*, it seems more in line with evidence from other groups that it arose from *Lonsdaleia* by a reduction of the columella. The ontogenetic evidence might equally well support this, the early growth-form being prolonged into maturity by simple neoteny.

It would seem unlikely that the stratigraphically higher *Waagenophyllum* developed from *Lonsdaleia* by the extension of the septa outwards to the epitheca. In the *Lithostrotion-Lithostrotionella* association there is some evidence to suggest that the latter developed from the former by a withdrawal of the septa from the epitheca. Since it is improbable that a trend would operate in two directions, the structure of the compound axial columns of *Waagenophyllum* and *Lonsdaleia* may well have arisen independently.

In the Lithostrotiontidae, *Diphyphyllum* and *Diphystrotion* have been shown to be associated as genomorphs with *Lithostrotion*. In the coral described below *Lithostrotionella* and *Thysanophyllum* are associated as genomorphs with *Lithostrotion*. It seems unlikely. therefore, that a *Lithostrotion* form developed independently from such forms as *Diphyphyllum*, *Lithostrotionella* and *Thysanophyllum*. *Lithostrotion* appears to represent a generalized type, the structure of which was open to modification in various ways. It has unspecialized septa, a simple columella, and is considered to be the most primitive of the corals discussed. *Thysanophyllum*, on the other hand, exhibits a twofold simplification in its structure, being without columella and with the septa withdrawn from the epitheca. This might easily have arisen in various ways, by the operation of two simplifying trends in such forms as *Lonsdaleia* and *Lithostrotion*. From *Lithostrotion* it could have developed in two ways depending on which trend was the first to operate, i.e. through *Diphystrotion* or through *Lithostrotionella*. It is thus hardly surprising that corals with a thysanophylloid structure have been associated by one authority or another with all of the above mentioned forms. Consequently it seems reasonable to conclude that *Lithostrotion* gave rise to extreme variations in certain definite directions which are distinguished as genomorphs, and that these genomorphs constitute anticipatory stages in the possible evolution of the group. That *Lithostrotion* itself is polyphyletic is a possibility that cannot be excluded, nor at the present time can any light be shed on the circumstances under which genomorphic variations take place.

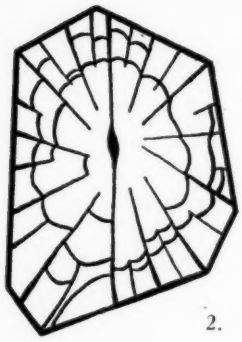
DESCRIPTION OF SPECIMEN

LITHOSTROTION sp.
Plate 103, text figures 2–4

The corallum is cerioid and, as far as could be seen, was approximately 8 ins. high and 12 ins. in diameter. The single large fragment collected measured 5 ins. high, 4½ ins. wide and 6 ins. long. The corallites are prismatic and show little variation in adult size, the majority being between 3 mm. and 4 mm. in average diameter. The epitheca shows faint longitudinal ridges and fine transverse striations. The calices have been destroyed by weathering on the upper side of the corallum. The corallites, which are well preserved, fall into three groups, between which there is complete gradation.

Group I. The *Lithostrotion* type of corallite.

There are 12 to 14 septa of each order, all of which are in contact with the epitheca. The lengths of the major septa vary, some



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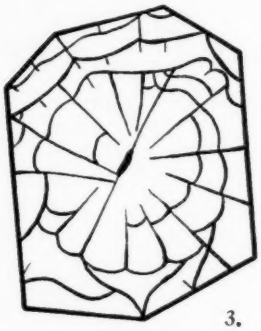

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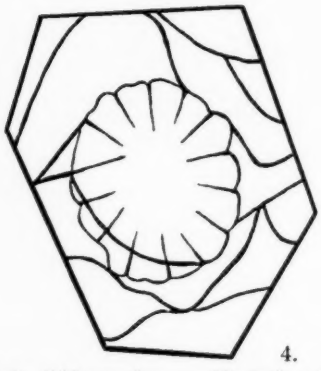


4.

FIGS. *2–4*—*Lithostrotion* sp., Variation in corallites. *2*, typical Group I corallite; *3*, Group II corallite showing some septa still in contact with the epitheca and an increase in size of the dissepiments; *4*, typical Group III corallite. ×12.

reach the columella, but the majority end about halfway across the tabularium. Most of the minor septa reach across the dissepimentarium, but in some corallites they are very short. The dissepiments are well-formed and inclined downwards at about 30 degrees towards the tabularium, one or two rows forming a dissepimentarium whose width varies from one-third to one-half of the radius. In transverse section the dissepiments form an inner wall which may be well-marked or broken and irregular between adjacent septa. The tabulae are gently domed, some of them being incomplete. Smaller tabulae may reinforce them at the edge of the tabularium. The columella is simple and may or may not be reached by septa.

Group. II. The *Lithostrotionella* type of corallite

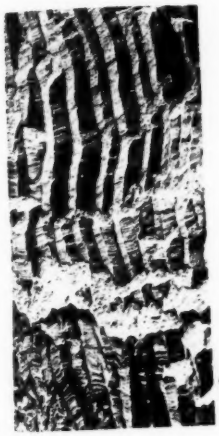
The major septa number 12 to 14 and are usually similar to those of Group I, but do not reach to the epitheca, from which they are separated by a dissepimentarium. The minor septa are reduced or absent. The dissepiments are in some cases similar to those of Group I but in others show a reduction in numbers and an increase in size. In corallites in which this reduction has taken place only a few large dissepiments show in transverse section. The tabulae and columella are similar to those in Group I.

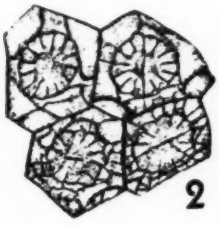
Group III. The *Thysanophyllum* type of corallite

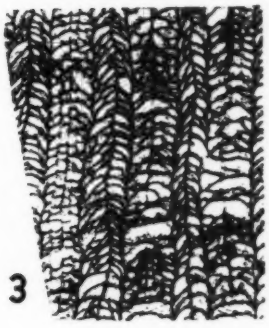
The major septa are similar to those in Group II, but are all withdrawn from the centre for at least half the radius of the tabularium. The dissepiments are reduced to a single row of large semicircular plates which form a conspicuous inner wall in transverse section. The tabulae are more widely spaced than in the other Groups, and are flat or very slightly domed. The columella is absent.

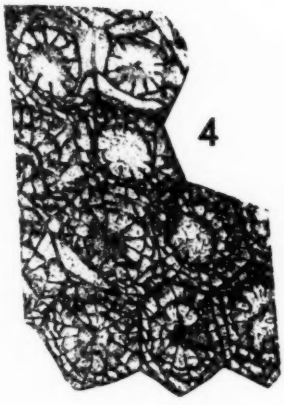
EXPLANATION OF PLATE 103

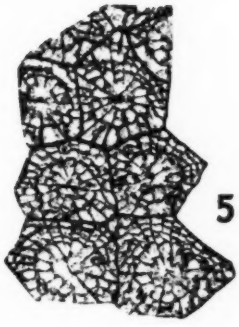
FIGS. *1–9*—*Lithostrotion* sp. Bull Creek, Prophet River, northeast British Columbia. Geological Survey of Canada Collection, no. 9666. *1*, Fragment of corallum, ×1. *2*, Transverse section of four corallites showing the three types of structure developed. *3*, Longitudinal section of corallites with Groups I or II septal structures. *4–6*, *8*, Transverse sections of corallites showing the variation between individuals and structures developed which approximate to Group I, II or III structures. *7*, *9*, Longitudinal sections of Group III corallites. Figs. *2–9* ×4. (p. 631)

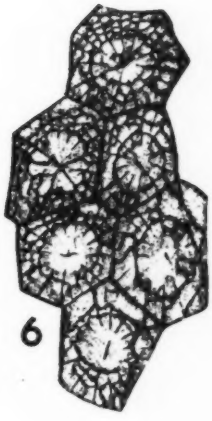


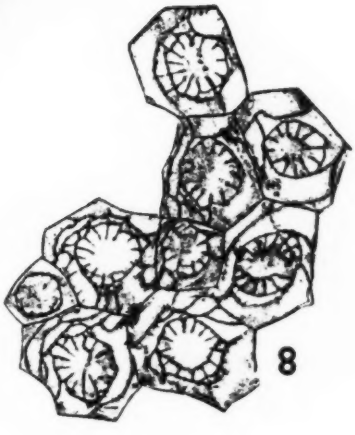












McLaren and Sutherland, *Lithostrotion*

Few of the corallites fall exactly into any of these three categories, although in general the Group II stage appears to be intermediate. The appearance of the large dissepiments seems to be variable compared with the appearance of the Group II septal structure. In many of this type of corallite, small septa occur along the epitheca or along dissepimental plates, in line with but not joined to the septa inside the inner wall. Types intermediate between Groups I and II have a varying number of septa joined with the epitheca, the remainder ending in the dissepimentarium. The proportions in which different types of corallites occur, as far as they can be differentiated are, very approximately: Group I 20 per cent, Group II 20 per cent, Group III 60 per cent.

As far as can be judged there is no appreciable change during the ontogeny of the individual corallites, e.g. immature Group III corallites show no signs of columella or of the septa outside the inner wall. The evidence on this point is weak, however, as the part of the corallum collected had very few immature individuals in it and none of them were of the *Lithostrotion* type.

The formation in which the fossil described above is found is sparingly fossiliferous. The fauna collected in association with the coral includes:

Hapsiphyllum calcariforme (Hall)
Neozaphrentis sp.
Productus cf. *arcuatus* Hall
"Orthotetes" sp.

A horizon some 150 feet lower in the same section yielded:

Dictyoclostus cf. *burlingtonensis* Hall
Spirifer n. sp. (of the *S. centronatus* group)
Schellwienella sp.
Echinoconchus biseriatus (Hall)

About 300 feet below the top of the section fossils were collected from the talus which included:

Lithostrotion pauciradiale (M'Coy)
Syringopora sp.

The above assemblages suggest a Mississippian age for the section, possibly Middle Mississippian. In the area in question, this formation is directly overlain by Triassic shales.

CONCLUSIONS

1. In the massive Carboniferous coral from northeast British Columbia discussed in this paper, the variation between individual corallites embraces structures which are typically developed in *Lithostrotion*, *Lithostrotionella* and *Thysanophyllum*.

2. This appears to be a striking confirmation of the genomorph concept, a principle formulated by Smith and Lang to explain a similar phenomenon in *Lithostrotion*, *Diphyphyllum* and *Diphystrotion*.

3. *Lithostrotionella* is a genomorph of *Lithostrotion*.

4. *Thysanophyllum* is a polyphyletic form which may have developed independently from *Lonsdaleia*, from *Lithostrotion* through *Diphystrotion*, or from *Lithostrotion* through *Lithostrotionella*.

5. *Lithostrotion* is believed to be the parent stock of the genomorphic forms mentioned, the various forms being developed by the action of two simplifying trends working at different relative rates.

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AN APPLICATION OF THE ANALYSIS OF VARIANCE TO PALEONTOLOGY

ROBERT L. MILLER
Department of Geology, University of Chicago

ABSTRACT—The analysis of variance, a statistical technique developed in recent years by R. A. Fisher and others, is described. It is believed to be a very useful tool in quantitative paleontology. An example of its application in a taxonomic problem is presented in detail.

INTRODUCTION

THE decision as to where to draw the line between likeness and difference within taxonomic groups, particularly species, has been almost exclusively based on subjective methods. The evaluation of morphologic variation should be removed from the realm of individual opinion, and treated quantitatively because a true appreciation of variation within a group is not possible without a statistical study. This is evidenced by the fact that conclusions regarding the limits and subdivisions of particular species have varied greatly from time to time.

In this paper, a quantitative method for determining the presence or absence of heterogeneity within a group is described and demonstrated. This method, properly used, should replace subjective analyses in areas of study where measurements and their mathematical interpretation are possible. The specific problem treated here is the differentiation of significant from non-significant morphological differences within a species, as based on the concept of probability.

No attempt has been made to restudy a species completely, because this would necessitate consideration of many matters not pertinent to this problem.

MATERIAL

In 1916 Haynes published the description of a new subspecies of *Spirifer whitneyi* Hall. In 1918 C. L. and M. A. Fenton published descriptions of three new subspecies of this same brachiopod and in 1924 they described and named two additional subspecies.[1] These descriptions are concerned only with external morphological characters and in each case the differences on which the authors based the new subspecies are summarized.

As much of the original material (including types) for five of these subspecies is available in the collections of Walker Museum, a quantitative study of the subspecies and their relations to the typical form of the species provides a good test of the particular biometric methods thought best fitted to such a problem.

The following specimens were studied:

Spirifer whitneyi HALL, cat. nos. U.C. 3011, 3026, 3026-8310, 8309, 20895, 20938, 20971, 25859, 25960, 25862, 25863, 25900, 25901, 25902, 25903, 26068. (Total of 82 specimens.)
Spirifer whitneyi HALL, plesiotypes (Fenton) U. C. 26066, U. C. 26067.
Spirifer whitneyi gradatus FENTON, 2 cotypes, U.C. 26027, 3 cotypes, U.C. 20022, 26025, 26026.
Spirifer whitneyi rockfordensis FENTON, holotype U.C. 26069, 2 specimens, U.C. 26070.
Spirifer whitneyi productus FENTON, holotype U.C. 26022, plesiotype (Fenton) U.C. 26023, 6 specimens, U.C. 25960, 25963.
Spirifer whitneyi subsiduus FENTON, paratype, U.C. 26077, 2 paratypes, U.C. 26072.
Spirifer whitneyi monticola HAYNES, 18 specimens, U.C. 28840.

The Fentons' specimens were collected from strata of the Hackberry Stage of the Devonian at several localities in Iowa; the specimens of *S. whitneyi monticola* Haynes, came from the Three Forks formation, Three Forks, Montana.

THE DATA

Data that may be useful in statistical studies fall into the following categories:

1. Measurements, i.e., length, width, thickness, angles.
2. Counts, i.e., number of costae.

[1] The word subspecies is used in this paper to include subdivisions that have commonly been called varieties.

3. Distributions, i.e., pattern of papillae, striae.
4. Presence or absence of certain characters, i.e., costae, papillae.

The following measurements and counts were made for each specimen studied except where the nature of its preservation made this impossible.

1. Total length.
2. Width measured along the hinge line (length of cardinal margin).
3. Thickness measured between the two widest points, normal to the plane of commisure.
4. Number of lateral costae, from edge of sinus to cardinal angle.
5. Number of costae in sinus.
6. Number of costae on fold.
7. Angle between fold and hinge line (right side).
8. Angle between fold and hinge line (left side).
9. Angle between sinus and hinge line (right side).
10. Angle between sinus and hinge line (left side).
11. Volume in c.c.
12. Width of delthyrium.
13. Length of delthyrium.
14. Radius of curvature of dorsal valve.
15. Radius of curvature of ventral valve.
16. Presence or absence of striae on the plications.
17. Presence or absence of convexity of anterior extremity of sinus.
18. Presence or absence of papillae.
19. Distribution of papillae (linear or random.)

These data were used as a basis for determining a series of characters treated by the analysis of variance. The term character as here used means specifically a descriptive condition or relationship which, in the opinion of the worker, may be logically used as a basis for separating distinct taxonomic groups. A character may be based on a single measurement or count, or on combinations of them as follows:

I. Characters of shape and form.
   A. Ratio of length to width.
   B. Ratio of length to thickness.

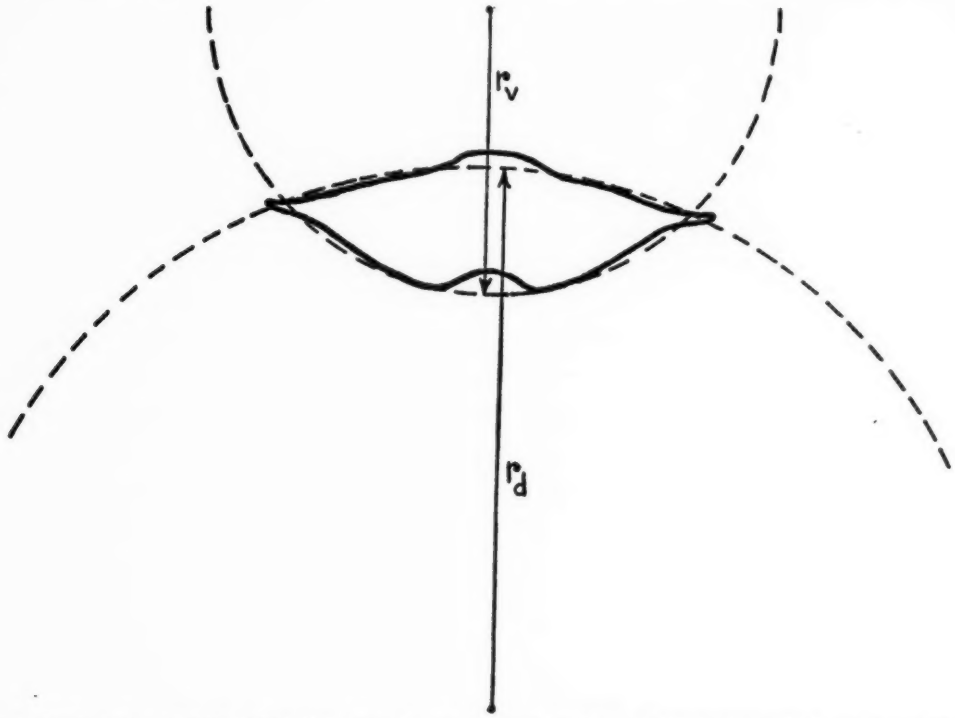

FIG. 1—Anterior profile of *Spirifer*. In order to express the degree of curvature of the valves, circles are superimposed over the profile of the shell. The radius of such a circle is an approximate measure of the degree of curvature of the valve. r_d = radius of curvature of dorsal valve, r_v = radius of curvature of the ventral valve.

C. Ratio of width to thickness.
D. Sphericity . . . the ratio of the volume of the circumscribing sphere to the volume of the specimen.[2] This ratio gives a measure of the approach of the shape of the specimen to a perfect sphere.
E. Radius of curvature of the dorsal valve. (See fig. 1 and accompanying explanation.[3])
F. Radius of curvature of the ventral valve.
G. Ratio of width of delthyrium to width of shell at hinge line.
H. Ratio of length of cardinal area to width of cardinal area.

II. Surface characters.
A. Angle between sinus and hinge line, both right and left sides.
B. Angle between fold and hinge line, both right and left sides.
C. Number of lateral costae from edge of sinus to cardinal angle

The costae on the fold and in the sinus of some specimens bifurcate. This is not peculiar to any of the subspecies considered and consequently individual counts of costae on the fold and in the sinus are not necessarily comparable.

APPLICATION OF ANALYSIS OF VARIANCE

If each of the six subspecies of *S. whitneyi* (including the "typical" form) is treated as a separate group, the hypothesis may be considered that all of these groups came from the same population,[4] i.e. each is part of a single homogeneous species. In accordance with this hypothesis, the variance within and between groups is considered to result only from chance.

If, however, the sum of the variances between groups exceeds the sum of the variances within groups, heterogeneity is present because the differences between groups is greater than can be attributed to chance alone. In other words, the differences between the individuals within the groups is not as great as the differences between the groups. If so, the foregoing hypothesis must be considered incorrect and the conclusion must be drawn that the groups were not derived from a single homogeneous population.[5]

The formulae used have been adapted from Tippet, 1945, where $\Sigma(\bar{x}_s-\bar{x})^2$ = the deviation of the mean of each group from the grand mean (all groups treated as one) squared and summed for all groups. $\bar{x}$ = grand mean, $\bar{x}_s$ = mean of group. $\Sigma\Sigma(x-\bar{x}_s)^2$ = the sum of squares of the deviations of individuals from the mean of their group, summed for all groups. x = individual, $\bar{x}_s$ = mean of group.

Variation	Sums of Squares	Degrees of Freedom	Variance
Between groups	$\sum(\bar{x}_s-\bar{x})^2$	$m-1$ m = No. of groups	$\dfrac{\sum(\bar{x}_s-\bar{x})^2}{m-1}$
Within groups	$\sum\sum(x-\bar{x}_s)$	$m(n-1)=N-m$ N = total no. of indiv. in all groups m = no. in each array	$\dfrac{\sum\sum(x-\bar{x}_s)}{N-m}$

The resulting variances are compared as a ratio $\dfrac{\text{variance between}}{\text{variance within}}=F$. The use of F, and a table for determining probability on the basis of a particular level of significance, are given by Snedecor, 1946, p. 212 ff.

This method was applied in turn to each of the eleven characters previously listed and heterogeneity was indicated to occur in five. The next step was to determine for each of these five characters, which of the groups, i.e. subspecies, differed significantly from *S. whitneyi s.s.* This was done by com-

[2] Krumbein and Pettijohn, 1938, pp. 283, 292–294.

[3] Ibid., The technique used in measuring the radius of curvature is described in Krumbein and Pettijohn, 1938, p. 298.

[4] The term population is used not in the biological but in the statistical sense, including all the individuals which have ever existed as *Spirifer whitneyi* with respect to each of the characters measured. This concept is inherent in the interpretations of probability that may result.

[5] A full discussion of the theory involved in the analysis of variance may be found in Fisher, 1946.

TABLE 1

Results of the comparisons of the mean of *S. whitneyi s.s.* with the means of the subspecies listed. The five characters used for making a separation are shown in the column at the left. The values of *t* with the proper number of degrees of freedom are entered in the table, and for comparison the value of *t* at .01 probability level is shown in parentheses. An asterisk indicates significantly large *t* values. In all other cases the probability of the resulting *t* value is given. In several tests the difference between means is so slight that it was not necessary to calculate *t*.

Character	The mean of *Spirifer whitneyi sensu strictu*, versus the mean of:				
	S. whitneyi rockfordensis	*S. whitneyi gradatus*	*S. whitneyi productus*	*S. whitneyi subsiduus*	*S. whitneyi monticola*
width / thickness	t=2.15 prob.=.05	d.f.=85 *t=4.20 (2.63)	d.f.=87 *t=4.09 (2.63)	d.f.=86 *t=2.86 (2.63)	d.f.=88 *t=4.47 (2.63)
sphericity	t=2.28 prob.=.02	d.f.=79 *t=4.09 (2.64)	d.f.=77 *t=2.77 (2.64)		d.f.=82 *t=4.79 (2.64)
length / width	t=2.30 prob.=.02	t=2.39 prob.=.02	d.f.=86 *t=3.13 (2.63)		d.f.=88 *t=4.93 (2.63)
radius of curvature (dorsal)			t=0.38 prob.=.76	d.f.=77 *t=7.46 (2.64)	d.f.=83 *t=13.10 (2.64)
radius of curvature (ventral)				d.f.=86 *t=8.33 (2.63)	d.f.=86 *t=13.50 (2.63)

paring the mean of each of these five characters for each subspecies in turn with the corresponding mean of *S. whitneyi s.s.* and testing for significant difference.

For this comparison the hypothesis was considered that the two means come from a single homogeneous population. The test is made by calculating the difference between the two means divided by the standard error of the difference. This value occupies a position in a *t* distribution and its significance can be determined from a table of probabilities.[6] The formula used is:

$$t = \frac{m_1 - m_2}{\sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}}$$

[6] A difficulty is presented by the choice of tables. The formula for the standard error of the difference between two means may be stated as follows; if the means of two samples have distribution which are normal and independent then the quantity ($\text{mean}_1 - \text{mean}_2$) is normally distributed with standard error;

$$\sigma_{m_1 - m_2} = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_1}}$$

With respect to sphericity it was found that *S. whitneyi monticola*, *S. whitneyi gradatus*, and *S. whitneyi productus*, differ significantly in their means from *S. whitneyi s.s.* (A summary of results is given in Table 1.) Thus a strong case is built up on the basis of heterogeneity within the species and significant differences of means, that the character of sphericity is valid for separating the above named subspecies from *S. whitneyi s.s.*

RESULTS

Of the eleven characters tested by the

However for small samples, the sample standard deviation is not an accurate estimate of the population parameter. Thus an error is introduced which increases as the sample size decreases, becoming serious for samples consisting of less than ten specimens.

Gosset, writing under the name of 'Student" determined a probability distribution which is based on the sample standard deviation rather than the universe parameter. It, rather than the normal distribution, was used in this study in referring to tables of probability values. The *t* table with appropriate degrees of freedom are given in Fisher, 1946.

method of analysis of variance, only five gave any evidence of heterogeneity. These five characters were then tested separately, as explained above to determine which are responsible for the heterogeneity. A summary of results is shown in Table 1.

For comparative purposes characters emphasized in the original description of the subspecies named by the Fentons and by Haynes are matched with the statistical results of the present study. These characters are presented and are followed by the present author's comments in parenthesis.

I. *Spirifer whitneyi rockfordensis* Fenton and Fenton.
   1. Ratio of sizes of dorsal and ventral valves (not statistically significant).
   2. Width much less, thickness greater (not statistically significant).
   3. Cardinal area much narrower (not statistically significant).
   4. Distinctive convexity of anterior extension of sinus. (This character was tested for presence or absence in *S. whitneyi s.s.* and found present in varying degrees. Therefore it could not be considered definitive of the subspecies *S. w. rockfordensis*.)

   On the basis of this study, this subspecies is not significantly different from *S.whitneyi s.s.*

II. *Spirifer whitneyi gradatus* Fenton.
   1. Considerably larger than *S. whitneyi s.s.* of the Hackberry. (Size, based on linear measurements is not significantly differerent from *S. whitneyi s.s.*, also the present author does not consider absolute difference of size to be significant for comparative purposes unless it can be established that equivalent growth stages are compared. The factor of differential growth rate introduces a serious complication.)
   2. Shape similar to that of *S. whitneyi rockfordensis*, but dorsal valve has less development than ventral. (What the Fentons meant by shape is not clear. However, a significant difference from *S. whitneyi s.s.* is demonstrated on the basis of sphericity which is a shape character.)

   This seems to be a valid subspecies but it is not recognizable on the basis of characters mentioned by the original authors.

III. *Spirifer whitneyi productus* Fenton and Fenton.
   1. General thinness of shell. (No absolute data are available on this character because only type specimens are available and these could not be sectioned.)
   2. Regularity of convexity of valves. (It is not clear what the Fentons meant. Amount of convexity, measured by radius of curvature, shows no significant difference.)
   3. Lack of cardinal projections of hinge line. (This condition was also noted in specimens of *S. whitneyi s.s.*)
   4. Absence of heavy growth lines. (The present author did not attempt to make a relative measure of growth lines. The correlation of such variation with heredity factors is very doubtful.)
   5. Papillae different in shape and distribution from those of *S. whitneyi s.s.* (The distribution of papillae does not differ statistically from that of *S. whitneyi s.s.* on the basis of tests of linear or nonlinear distribution. Variation in shape of the papillae was not studied.)

   This subspecies does not seem to be recognizable on the basis of any of the characters mentioned above but the sphericity test indicates that it is distinct.

IV. *Spirifer whitneyi monticola* Haynes.
   1. Greater rotundity than in the Iowa form of *S. whitneyi s.s.* (significant).
   2. Ratio of length to width measured along the hinge line, less than in *S. whitneyi s.s.* (significant).
   3. Ratio of length to thickness less (significant).
   4. Fine striae on broad flattened radiating plications present only in *S. whitneyi monticola*. (This condition was not noted in any of the specimens of *S. whitneyi s.s.*)

   In addition the radius of curvature of both dorsal and ventral valves was found to be significantly greater than in *S. whitneyi s.s.* This subspecies is distinctly different from *S. whitneyi s.s.* and possibly it should be considered a distinct species, if morphology alone is to be considered.

CONCLUSIONS

The conclusions reached as a result of this study are of two types. The first is specific and has to do with the treatment of subspecies of *Spirifer whitneyi* Hall, used as an example in this paper. The second is general and is concerned with the validity and usefulness of the methods described.

Of the subspecies proposed by the Fentons and tested by the author, three stand up under statistical analysis, although not in every case on the basis of those characters described by the original authors. Some differences, which seem to be important, are shown by a statistical analysis to be of no significance. On the other hand statistical tests have brought to light differences that had not been noticed previously. The four subspecies which are recognizably distinct are *S. whitneyi gradatus*, *S. whitneyi productus*, *S. whitneyi subsiduus*, and *S. whitneyi monticola*. However, the fifth subspecies studied, *S. whitneyi rockfordensis*, cannot be statistically separated from *S.*

whitneyi s.s. either on the basis of the characters noted by the Fentons or additional characters tested by the present author.

On the basis of characters measured and tested for significant differences, *S. whitneyi monticola* Haynes, was found to be the most sharply defined of the subspecies analyzed in this paper.

Many articles have been written, chiefly in the field of vertebrate paleontology, in which quantitative methods have been used. Very few, however, have been concerned with the application of statistics to problems of a general nature. The purpose of this paper is to present a workable quantitative method for the breakdown of heterogeneous groups. This method is useful not only in reanalyzing established groups, but also in the study of new forms.

The method of analysis described here appears to be a practical means for evaluating the significance of any apparent differences that can be expressed by measurements or counts. It should be particularly useful when applied to the problem of the recognition of new subspecies or species. Its successful use is dependent, however, upon the existence of a statistical standard. This requires a thorough statistical analysis of an adequate number of "typical" specimens with which other groups of specimens can be compared. The application of this method would be greatly facilitated if the descriptions of all new species were accompanied by such a statistical analysis.

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BIBLIOGRAPHY AND INDEX TO NEW GENERA, SPECIES, AND VARIETIES OF FORAMINIFERA FOR THE YEAR 1948

HANS E. THALMANN
Caracas, Venezuela

ABSTRACT—The following bibliography lists for the year 1948 three hundred and twenty-one papers devoted partly or exclusively to Foraminifera. Several titles are added for previous years.

The Index to new genera, species, and varieties (subspecies) of Foraminifera for the year 1948 records as new: 2 families, 37 genera (including two *nomina nova*), 1 subgenus, 301 species, 31 varieties, 15 nomina nova, 11 nomina nuda, 3 homonyms of which one has already been changed during 1948, and 117 forms to which the nomenclatura aperta was applied.

The three homonyms erected during 1948 are, as follows:

Bolivina astoriensis Rau, preoccupied by Cushman, R. E. and K. C. Stewart, 1947 (1948). (According to a letter received by W. W. Rau, dated February 1, 1949, this homonym will be changed to: *Bolivina chehalisensis* Rau, nom. nov.).

Eponides abatissae (Selli, 1944) var. *multicameratus* Petters and Gandolfi, preoccupied by *Eponides multicameratus* Kleinpell, 1938. (V. Petters has been requested to substitute a new name by letter, dated March 22, 1949).

Planulina limbata Brotzen, preoccupied by Natland, 1938, and renamed during 1948: *Planulina scanica* Brotzen, nom. nov.

The compiler regrets to state that little information regarding literature on Foraminifera published in Russia and several East-European countries has reached him since the war. An appeal is, therefore, made to all those workers in Foraminifera who may have access to Russian literature to kindly furnish pertinent data for the bibliography and index to the writer.

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Alabamina midwayensis Brotzen, *nom. nov.*, Sver. geol. Unders. Ser. C, No. 493, Arsbok 42, No. 2; p. 99, pl. 16, figs. 1, 2; text fig. 26-B (not text fig. 25). Paleocene, Sweden. New name for: *Pulvinulina exigua* (Brady) in Plummer, 1926, Univ. Texas Bull. 2644, p. 150, pl. 11, fig. 3. (For further synonymies see original paper).
——— *solnäsensis* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 102, pl. 16, fig. 4. Paleocene, Sweden.
Allomorphina paleocenica Cushman, Cushman Lab. Foram. Res., Contr., vol. 24, p. 45, pl. 8, fig. 10. Paleocene, Texas. For: *Allomorphina trigona* (Reuss) in Plummer, 1926 (1927), Bull. Univ. Texas 2644, p. 129, pl. 8, fig. 5; for same species in Kline, 1943, Bull. 53, Miss. State Geol. Surv., p. 56, pl. 6, figs. 1, 2; and for same species in Cushman and Todd, 1946, Cushman Lab. Foram. Research. Contr., vol. 22, p. 63, pl. 11, figs. 11 and 15.
AMMOASTUTA gen. nov. Cushman and Bronnimann, Cushman Lab. Foram. Res., Contr., vol. 24, p. 17. Fam. Lituolidae. Genotype: *Ammoastuta salsa* Cushman and Bronnimann, *ut infra.* Recent (brackish water).
——— *salsa* Cushman and Bronnimann, *ibid.*, vol. 24, p. 17, pl. 3, figs. 14–16. Recent, brackish water, West coast of Trinidad, B.W.I.
Ammobaculites dilatatus Cushman and Bronnimann, *ibid.*, vol. 24, p. 39, pl. 7, figs. 10, 11. Recent, Gulf of Paria, 0–2 fathoms, Trinidad, B.W.I.
——— *directus* Cushman and Bronnimann, *ibid.*, vol. 24, p. 38, pl. 7, figs. 3, 4. Recent, Gulf of Paria, 0–2 fathoms, Trinidad, B.W.I.
——— *diversus* Cushman and Bronnimann, *ibid.*, vol. 24, p. 38, pl. 7, figs. 5, 6. Recent, Gulf of Paria, 0–2 fathoms, Trinidad, B.W.I.

——— *exiguus* Cushman and Bronnimann, *ibid.*, vol. 24, p. 38, pl. 7, figs. 7, 8. Recent, Gulf of Paria, 0–2 fathoms, Trinidad, B.W.I.

——— *exilis* Cushman and Bronnimann, *ibid.*, vol. 24, p. 39, pl. 7, fig. 9. Recent, Gulf of Paria, 0–2 fathoms, Trinidad, B.W.I.

——— *pseudocassis* Cushman and Bronnimann, *ibid.*, vol. 24, p. 39, pl. 7, fig. 12. Recent, West coast of Trinidad, B.W.I. (brackish water).

——— *salsus* Cushman and Bronnimann, *ibid.*, vol. 24, p. 16, pl. 3, figs. 7–9. Recent, West coast of Trinidad, B.W.I., (brackish water).

——— ——— ——— var. *distinctus* Cushman and Bronnimann, *ibid.*, vol. 24, p. 40, pl. 7, figs. 13, 14. Recent, Gulf of Paria, Trinidad, B.W.I., 0–2 fathoms.

Ammodiscus gullmarensis Höglund, *nom. nov.*, *ibid.*, vol. 24, p. 45. New name for: *Ammodiscus planus* Höglund, 1947 (non Loeblich, 1946), Zool. Bidr. Uppsala, vol. 26, p. 123, pl. 8, figs. 2, 3, 8; pl. 28, figs. 17, 18; text figs. 85–89, 105, 106, 109. Recent, North Sea.

Amphimorphina gracilis Cushman and Todd, *ibid.*, vol. 24, p. 3, pl. 2, figs. 1, 2. Upper Eocene, Mississippi.

——— *miocenica* Cushman, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 220, pl. 15, figs. 16–18. Miocene, Maryland. For: *Amphimorphina sp.* Cushman and Ponton, 1932, Bull. 9, Florida State Geol. Surv., p. 75, pl. 11, figs. 4–6.

Angulogerina agrestis Todd, in Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 288, pl. 36, fig. 6. Recent, Pacific, off California, 17 fathoms.

——— *albatrossi* Cushman, 1932, var. *hirsuta* Todd, in Cushman and McCulloch, *ibid.*, vol. 6, no. 5, p. 278, pl. 35, fig. 4. Recent, Pacific, 60 fathoms.

——— *carinata* Cushman, 1927, var. *vana* Todd, in Cushman and McCulloch, *ibid.*, vol. 6, no. 5, p. 287, pl. 35, fig. 10. Recent, Pacific, off California, 285 fathoms.

——— *charapotoensis* Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 63, pl. 10, fig. 8. Miocene, Ecuador.

——— *cuneata* Brotzen, Sver. geol. Unders., Ser. C, No. 493, Arsbok 42, no. 2, p. 64, pl. 6, fig. 10. Paleocene, Sweden.

——— *elliptica* Dorreen, Jour. Paleontology, vol. 22, p. 293, pl. 38, fig. 9. Upper Eocene, New Zealand.

——— *exigua* Cushman, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 238, pl. 15, fig. 13. Eocene, Maryland.

——— *fornasinii* Selli, Soc. Ital. Sci. Nat. Atti, vol. 87. (described and figured, but not seen by the compiler).

——— *hughesi* (Galloway and Wissler, 1927) var. *picta* Todd, in Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 290. pl. 36, fig. 3. Recent, Pacific, off California, 60 fathoms.

Anomalina clementina (d'Orbigny, 1840), var. *assimilis* Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24, p. 74, pl. 12, fig. 17. Paleocene, Cuba.

——— *cubana* Cushman and Bermudez, *ibid.*, vol. 24, p. 86, pl. 15, figs. 7–9. Paleocene, Cuba. (Cave: *Anomalina cubensis* van Bellen, 1941).

——— *madrugaensis* Cushman and Bermudez, *ibid.*, vol. 24, p. 86, pl. 15, figs. 4–6. Paleocene, Cuba.

——— *martinezensis* Cushman and Bermudez, *ibid.*, vol. 24, p. 74, pl. 12, figs. 14–16, Paleocene, Cuba.

——— *praespissiformis* Cushman and Bermudez, *ibid.*, vol. 24, p. 86, pl. 15, figs. 1–3. Paleocene, Cuba.

——— *sigmocosta* ten Dam, Jour. Paleontology, vol. 22, p. 189, pl. 32, figs. 23, 24. Neocomian, Holland.

——— *tenuissima* (Reuss, 1856) var. *jongmansi* van Bellen, *nom. nov.*, Cushman Lab. Foram. Res., Contr., vol. 24, p. 76. Eocene, Dalmatia. New name for: *Anomalina tenuissima* (Reuss) var. *evoluta* van Bellen, 1941, (non *Anomalina variolata* d'Orbigny var. *evoluta* Walther, 1888), Proc. Nederl. Akad. Wetensch., vol. 44, p. 1001, fig. 25.

Anomalinoides aspera Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, no. 2, p. 88, pl. 15, fig. 4. Paleocene, Sweden.

——— *nobilis* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 89, pl. 19, fig. 5. Paleocene, Sweden.

Arenobulimina möhreni Brotzen, *ibid.*, Arsbok 42, No. 2, p. 35, pl. 6, fig. 1. Paleocene, Sweden.

Arenodosaria kaiataensis Dorreen, Jour. Paleontology, vol. 22, p. 287, pl. 36, fig. 5. Upper Eocene, New Zealand.

Astacolus gryi Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, No. 2, p. 44, pl. 7, fig. 6; text figs. 8 e–g. Paleocene, Sweden.

——— *paleocenicus* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 43, pl. 7, fig. 7; text figs. 8 a–d. Paleocene, Sweden.

Asterigerina cyclops Dorreen, Jour. Paleontology, vol. 22, p. 297, pl. 40, fig. 5. Upper Eocene, New Zealand.

——— *nörvangi* Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, No. 2, p. 126, pl. 18, figs. 4, 5. Paleocene, Sweden.

ATAXOPHRAGMOIDES gen. nov. Brotzen, *ibid.*, Arsbok 42, No. 2, p. 35. Family not stated (Valvulinidae). Genotype: *Ataxophragmoides frankei* Brotzen, 1948 *ut infra*. Upper Maestrichtian, Danian and Paleocene.

——— *frankei* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 36, pl. 5, fig. 6. Paleocene, Sweden. For: *Bulimina variabilis* Franke, 1927 (non d'Orbigny, 1840), Danmarks Geol. Unders., vol. 2, No. 46, p. 11, pl. 1, fig. 7.

Baggina washingtonensis Rau, Jour. Paleontology, vol. 22, p. 779, pl. 119, figs. 24–27. Lower Miocene, Washington, U.S.A.

BIGLOBIGERINELLA gen. nov. Lalicker, *ibid.*, vol. 22, p. 624. Family Globigerinidae. Genotype: *Biglobigerinella multispina* Lalicker, 1948, *ut infra*. Upper Cretaceous.

——— *multispina* Lalicker, *ibid.*, vol. 22, p. 624, pl. 92, figs. 1–3. Upper Cretaceous, Arkansas.

Boldia carinata Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24, p. 75, pl. 11, figs. 11–13. Paleocene, Cuba.

——— *cubensis* Cushman and Bermudez, *ibid.*, vol. 24, p. 74, pl. 11, figs. 15, 16. Paleocene, Cuba.

——— *madrugaensis* Cushman and Bermudez, *ibid.*, vol. 24, p. 75, pl. 12, figs. 4–6. Paleocene, Cuba.

Bolivina astoriensis Rau, Jour. Paleontology, vol. 22, p. 778, pl. 119, fig. 7. Lower Miocene, Washington. (Note: The species name of Rau was published on December 31, 1948 and becomes, therefore, a homonym of *Bolivina astoriensis* Cushman, Stewart and Stewart, 1947, State of Oregon Dept. Geol. and Min. Industr., Bull. 36, pt. 2, p. 47, pl. 6, fig. 3, from the Miocene Astoria formation of Oregon, published May 28, 1948. According to a letter received from W. W. Rau, dated February 1, 1949, the homonym will be changed to *Bolivina chehalisensis* Rau, *nom. nov.*)

——— *calvertensis* Dorsey, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 306, pl. 36, fig. 17. Miocene, Maryland.

——— *charapotoensis* Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 61, pl. 10, figs. 1, 2. Miocene, Ecuador.

——— *dispar* Cushman and Stevenson, *ibid.*, vol. 24, p. 60, pl. 9, fig. 35. Miocene, Ecuador.

——— *ecuadorana* Cushman and Stevenson, *ibid.*, vol. 24, p. 60, pl. 9, figs. 33, 34. Miocene, Ecuador.

——— *granti* Rankin, 1934, var. *denticulata* Cushman and Stevenson, *ibid.*, vol. 24, p. 59, pl. 9, fig. 37. Miocene, Ecuador.

——— *ödumi* Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, no. 2, p. 65, pl. 9, figs. 3, 4. Paleocene. Sweden.

——— *paleocenica* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 66, pl. 9, fig. 5. Paleocene, Sweden.

——— *scintillo* Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 4, pl. 2, fig. 5. Upper Eocene, Mississippi.

——— *thalmanni* H. H. Renz, Geol. Soc. America, Mem. no. 32, p. 120, pl. 12, fig. 13. Basal Miocene, Falcon, Venezuela.

Bolivinopsis (*Spiroplectoides*) *scanica* Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 54, pl. 6, fig. 3; text fig. 14. Paleocene, Sweden.

BONTOURINA gen. nov. Caudri. Jour. Paleontology, vol. 22, p. 477. Family Orbitoididae. Genotype: *Bontourina inflata* Caudri, 1948, *ut infra*. Paleocene. Pro: *Hexagonocyclina* Caudri, 1944 (non *Exagonocyclina* Checchia-Rispoli, 1908), Bull. Amer. Paleontology, vol. 18, No. 114, p. 12.

——— *inflata* Caudri, *ibid.*, vol. 22, p. 477, footnote 8. No description; pl. 173, fig. 6; pl. 74, fig. 5. Reworked Paleocene in Upper Eocene, Trinidad, B.W.I.

BROECKINELLA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia (Brit. Mus. Nat. Hist.), p. 92. Family: Meandropsinidae. Genotype: *Broeckinella arabica* Henson, 1948, *ut infra*. Maestrichtian.

——— *arabica* Henson, *ibid.*, (Brit. Mus. Nat. Hist.), p. 93, pl. 7, fig. 6; text fig. 13. Maestrichtian, Arabia.

Bulimina aspero-aculeata Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 60, pl. 6, fig. 4; pl. 10, figs. 6, 7. Paleocene, Sweden.

——— *ecuadorana* Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 58, pl. 9, figs. 25, 26. Miocene, Ecuador.

——— *falconensis* H. H. Renz, Geol. Soc. America, Mem. no. 32, p. 121, pl. 6, fig. 15. Uppermost Oligocene, Falcon, Venezuela. For: *Bulimina buchiana* Cushman and Ponton, 1932 (non d'Orbigny, 1846), Florida State Geol. Surv., Bull. 9, p. 78, pl. 12, fig. 1.

——— (*Reussella*) *paleocenica* Brotzen, Sverig. geol. Unders., Ser. C. No. 493, Arsbok 42, No. 2, p. 61, pl. 6, figs. 5, 6. Paleocene, Sweden.

——— *rosenkrantzi* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 61, pl. 9, fig. 1; pl. 10, fig. 5. Paleocene, Sweden.

——— *uvigeriniformis* Cushman and Kleinpell, 1934, var. *charapotoensis* Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 58, pl. 9, fig. 24, Miocene, Ecuador.

Buliminella constrictula Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 58, pl. 10, figs. 1, 2. Paleocene, Sweden.

——— *ecuadorana* Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 57, pl. 9, figs. 19, 20. Miocene, Ecuador.

——— *elegantissima* (d'Orbigny, 1939) var. *limbosa* Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 238, pl. 29, fig. 5. Recent, Pacific, off Peru, 22 fathoms.

——— ——— (———) var. *tenuis* Cushman and McCulloch, *ibid.*, vol. 6, no. 5, p. 238, pl. 29, fig. 6. Recent, Pacific, off California, 20 fathoms.

——— *parvula* Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, no. 2, p. 57, pl. 10, figs. 3, 4. Paleocene, Sweden.

Ceratobulimina tuberculata Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 124, pl. 19, figs. 2, 3. Paleocene, Denmark.

Chrysalidinella spectabilis Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 256, pl. 32, figs. 1–7. Recent, Pacific, off Lower California, 50 fathoms.

Cibicides ekblomi Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, no. 2, p. 82, pl. 13, fig. 2. Paleocene, Sweden.

——— *elmaensis* Rau, Jour. Paleontology, vol. 22, p. 173, pl. 31, figs. 18–26. Upper Eocene, Washington.

——— *falconensis* H. H. Renz, Geol. Soc. America, Mem. no. 32, p. 128, pl. 11, figs. 6, 7. Lower part of Upper Oligocene, Falcon, Venezuela.

——— *lalickeri* Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 37, pl. 6, figs. 35–37. Eocene, Cook Mountain formation, Mississippi.

——— *madrugaensis* Cushman and Bermudez,

ibid., vol. 24, p. 87, pl. 15, figs. 10–12. Paleocene, Cuba.

——— *mammilatus* Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, no. 2, p. 81, pl. 10, fig. 15. Paleocene, Sweden.

——— *marylandicus* Shifflett, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 3, p. 74, pl. 5, figs. 4–6. Lower Eocene (Wilcox), Maryland.

——— *mirificus* Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24, p. 88, pl. 16, figs. 1–3. Paleocene, Cuba.

——— *perforatus* (Karrer, 1864) var. *notocenicus* Dorreen, Jour. Paleontology, vol. 22, p. 299, pl. 41, fig. 4. Upper Eocene, New Zealand.

——— *reprimatus* Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24 p. 87, pl. 15, figs. 13, 14. Paleocene, Cuba.

——— *sahlströmi* Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, no. 2, p. 85, pl. 17, fig. 1. Paleocene, Sweden.

——— *salsoensis* Petters and Gandolfi, Riv. Ital. Pal. e Strat., vol. 54, fasc. 3, p. 11, pl. 1, fig. 5. Oligocene, Italy.

——— *simplex* Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, no. 2, p. 83, pl. 13, figs. 4, 5. Paleocene, Sweden.

——— *succedens* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 80, pl. 12, fig. 1; text fig. 21. Paleocene, Sweden. For: *Cibicides cryptomphalus* (Reuss) var. *hercegoviensis* de Witt Puyt, in ten Dam, 1944, Mededeel. Geol. Sticht. Haarlem, Ser. C., vol. 5, No. 3, p. 132, pl. 5, fig. 9.

——— *umbilicata* Brotzen, *ibid.*, Arsbok 42, no. 2, p. 84, pl. 13, fig. 6. Paleocene, Sweden.

——— *vortex* Dorreen, Jour. Paleontology, vol. 22, p. 299, pl. 41, fig. 5. Upper Eocene, New Zealand.

Cibicidoides proprius Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 78, pl. 12, figs. 3, 4. Paleocene, Sweden. For: *Cibicides praecursorius* (Schwager) in Toulmin, 1941, Jour. Paleontology, vol. 15, p. 610, pl. 81, figs. 19, 20; and for: *Cibicides cryptomphalus* (Reuss) in ten Dam, 1944. Mededeel. Geol. Sticht. Haarlem, Ser. C., vol. 5, no. 3, p. 132, pl. 1, fig. 4.

Coleites abuillotensis Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24, p. 83, pl. 14, figs. 1, 2. Lower Eocene, Haiti.

——— *danicus* Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, no. 2, p. 113, pl. 18, fig. 2. Paleocene, Sweden.

——— *guatemalensis* Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24, p. 84, pl. 14, figs. 3–5. Lower Eocene, Guatemala.

——— *pasionensis* Cushman and Bermudez, *ibid.*, vol. 24, p. 84, pl. 14, fig. 6. Lower Eocene, Guatemala.

COLOMIA gen. nov. Cushman and Bermudez, *ibid.*, vol. 24, p. 12. Family Genotype: *Colomia cretacea* Cushman and Bermudez, 1948, *ut infra*. Upper Cretaceous.

——— *cretacea* Cushman and Bermudez, *ibid.*, vol. 24, p. 12, pl. 2, figs. 13–15. Upper Cretaceous, Cuba.

COSKINOLINOPSIS gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, (Hist.), p. 27. Family: Orbitolinidae. Genotype: *Coskinolinopsis primaevus* Henson, 1948, *ut infra*. Upper Triassic or Lower Jurassic.

——— *primaevus* Henson, *ibid.*, (Brit. Mus. Nat. Hist.), p. 28, pl. 10, figs. 4, 5, 7, 13, 12. Upper Triassic ? or Lower Jurassic, Oman and Cyprus.

CRIBROELPHIDIUM gen. nov. Cushman and Bronnimann, Cushman Lab. Foram. Res., Contr., vol. 24, p. 18. Family Nonionidae. Genotype: *Cribroelphidium vadescens* Cushman and Bronnimann, 1948, *ut infra*. Recent (Brackish Water).

——— *kugleri* Cushman and Bronnimann, *ibid.*, vol. 24, p. 18, pl. 4, fig. 4. Recent, off Westcoast of Trinidad, B.W.I., brackish water.

——— *limosum* Cushman and Bronnimann, *ibid.*, vol. 24, p. 19, pl. 4, fig. 7. Recent, West-coast of Trinidad, B.W.I., brackish water.

——— *salsum* Cushman and Bronnimann, *ibid.*, vol. 24, p. 19, pl. 4, fig. 6. Recent, off Westcoast of Trinidad, B.W.I., brackish water.

——— *trinitatensis* Cushman and Bermudez, *ibid.*, vol. 24, p. 20, pl. 4, fig. 8. Recent, off West-coast Trinidad, B.W.I., brackish water.

——— *vadescens* Cushman and Bronnimann, *ibid.*, vol. 24, p. 18, pl. 4, fig. 5. Recent, off West-coast of Trinidad, B.W.I., brackish water.

CRIBROPARELLA gen. nov. ten Dam, Jour. Paleontology, vol. 22, p. 486. Family (*recte: Discorbisidae*), subfamily Discorbinae (*recte:* Discorbisinae). (Note: the new generic name is misspelled and should read: *CRIBROPARRELLA*). Genotype: *Cribroparrella regadana* ten Dam, 1948, *ut infra*. Upper Miocene.

——— *regadana* ten Dam, *ibid.*, vol. 22, p. 486, pl. 76, figs. 1–3. Upper Miocene, Algeria.

Cyclammina greigi Henson, Larger Imperforate Foram. S.-W. Asia, (Brit. Mus. Nat. Hist.), p. 13, pl. 13, figs. 9, 11. Basal Cretaceous, Arabia.

——— *whitei* Henson, *ibid.*, (Brit. Mus. Nat. Hist.), p. 13, pl. 13, figs. 3, 12–14. Lower to Middle Cretaceous, Arabia.

DICTYOCONELLA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, (Brit. Mus. Nat. Hist.), p. 24. Family Orbitolinidae. Genotype: *Dictyonella complanata* Henson, 1948, *ut infra*, Upper Cenomanian to Maestrichtian.

——— *complanata* Henson, *ibid.*, Brit. Mus. Nat. Hist., p. 25, pl. 6, figs. 2, 3, 16; pl. 10, fig. 14. Maestrichtian, Arabia.

——— *minima* Henson, *ibid.*, Brit. Mus. Nat. Hist., p. 25, p. 11, figs. 3, 8–10. Upper Cenomanian or Turonian, Arabia.

Dictyoconus arabicus Henson, *ibid.*, Brit. Mus. Nat. Hist., p. 35, pl. 1, figs. 5–8; pl. 14, figs. 1–12. Barremian, Arabia; Aptian-Cenomanian, Iran.

Discocyclina (*Discocyclina*) *andrusovi* de Cizancourt, Stat. geol. Ustav. Bratislava, vol. 17, p. 52, pl. 7, fig. 15; pl. 8, fig. 21; pl. 9, figs. 22, 26, 29; text fig. 1. Eocene, Czechoslovakia. For:

Discocyclina aff. varians Kaufmann in Brönnimann, 1940. Eclog. geol. Helvetiae, vol. 33, p. 261, pl. 14, figs. 1–6; pl. 15, figs. 3, 4.

Discorbis amicus Shifflett, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 3, p. 65, pl. 3, fig. 19. Lower Eocene (Wilcox), Maryland.

——— *calyptra* Shifflett, *ibid.*, Bull. 3, p. 65, pl. 3, fig. 20. Lower Eocene, (Wilcox), Virginia.

——— *cavernata* Dorsey, *ibid.*, Bull. 2, p. 311, pl. 37, fig. 3. Miocene, Maryland.

——— *finlayi* Dorreen, Jour. Paleontology, vol. 22, p. 293, pl. 38, fig. 12. Upper Eocene, New Zealand.

——— *warreni* Dorsey, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 310, pl. 37, fig. 5. Miocene, Maryland. For: ? *Discorbis floridana* Cushman, 1932 (non Cushman, 1922), Florida State Geol. Surv. Bull. 9, p. 88, p. 13, fig. 2; and for: same species in Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Pap. 175-A, p. 29, pl. 9, fig. 12.

Discorinopsis vadescens Cushman and Bronnimann, Cushman Lab. Foram. Res., Contr., vol. 24, p. 20, pl. 4, figs. 9, 10. Recent, off Westcoast of Trinidad, B.W.I., brackish water.

DOHAIA gen. nov. Henson, Larger Imperforate Foram. S.W. Asia, Brit. Mus. Nat. Hist. Family Meandropsinidae. Genotype: *Dohaia planata* Henson, 1948, *ut infra*. Middle Cretaceous (Upper Cenomanian-Turonian).

——— *planata* Henson, *ibid.*, Brit. Mus. Nat. Hist., p. 101, pl. 7, fig. 12; pl. 10, ? fig. 16; pl. 11, figs. 4, 5. Upper Cenomanian-Turonian, Arabia.

Dorothia ? *almadenenis* Cushman and Todd, Cushman Lab. Foram. Res. Contr., vol. 24, p. 94, pl. 16, figs. 11, 12. Cretaceous ?, California.

EDOMIA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 84, Family Meandropsinidae. Genotype: *Edomia reicheli* Henson, 1948, *ut infra*. Middle Cretaceous (Cenomanian-Turonian).

——— *iranica* Henson, *ibid.*, Brit. Mus. Nat. Hist., p. 86, pl. 6, figs. 8–11. Middle Cretaceous, Iran.

——— *reicheli* Henson, *ibid.*, Brit. Mus. Nat. Hist., p. 85, pl. 8, figs. 1–14. Cenomanian, Palestine.

Ellipsoglandulina glabra Cushman and H. H. Renz, Cushman Lab. Foram. Res., Contr., Spec. Publ. Contr. 24, p. 33, pl. 6, fig. 18. Eocene, Trinidad, B.W.I.

Ellipsonodosaria calvertensis Cushman, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 223, pl. 15, figs. 14, 15. Miocene, Maryland.

——— *nuttalli* Cushman and Jarvis, 1934, var. *aculeata* Cushman and H. H. Renz, Cushman Lab. Foram. Res., Spec. Publ. 24, p. 32, pl. 6, fig. 10. Upper Eocene, Trinidad, B.W.I.

——— *pilulata* Cushman and Todd, *ibid.*, Contr. vol. 24, p. 5, pl. 2, fig. 8. Upper Eocene, Mississippi.

Elphidium ingressans Dorreen, Jour. Paleontology, vol. 22, p. 290, pl. 37, fig. 10. Upper Eocene, New Zealand.

——— *nitidum* Dorreen, *ibid.*, vol. 22, p. 290, pl. 37, fig. 11. Upper Eocene, New Zealand.

——— *omotoensis* Dorreen, *ibid.*, vol. 22, p. 290, pl. 37, fig. 12. Upper Eocene, New Zealand.

Entosolenia marginata (Montagu, 1803) var. *lisbonensis* Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 33, pl. 6, fig. 13. Eocene, Mississippi.

——— *oslatus* Shifflett, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc. Bull. 3, p. 62, pl. 3, fig. 14. Lower Eocene (Wilcox), Virginia.

——— *unicospina* Cushman and H. H. Renz, Cushman Lab. Foram. Res., Spec. Publ. 24, p. 26, pl. 5, fig. 18. Eocene, Trinidad, B.W.I.

Eoschubertella mexicana Thompson, Univ. Kansas Pal. Contr., Protozoa, Art. 1, p. 79, pl. 28, figs. 1–8. Pennsylvanian, N. Mexico.

Epistomina chapmani ten Dam, *nom. nov.*, Rev. Inst. Franç. Pétrole et Ann. Combust. Liquides, vol. 3, p. 166, pl. 1, fig. 5. Lower Albian, Holland. New name for: *Rotalia elegans* Jones and Parker, 1860 (non d'Orbigny, 1826), Geol. Soc. London, Quart. Jour., vol. 16, pl. 20, fig. 46; for: *Pulvinulina caracolla* Chapman, 1898, (non Roemer, 1841), Roy. Micr. Soc. London, Jour., (2), vol. 18, p. 7, pl. 1, fig. 9: for: *Pulvinulina elegans* Chapman, 1898, (non d'Orbigny, 1826), *ibid.*, (2) vol. 18, p. 6, pl. 1, fig. 8; and for: *Epistomina elegans* Eichenberg, 1933, (non d'Orbigny, 1826), Niedersächs. geol. Vereinig. Jahresber., p. 22, pl. 7, fig. 1 (non pl. 4, fig. 2).

——— *reticulata* (Reuss, 1862) var. *suturalis* ten Dam, *ibid.*, vol. 3, p. 169, pl. 2, fig. 7. Lower Albian, Holland.

——— *supracretacea* ten Dam, *nom. nov. ibid.*, vol. 3, p. 163, pl. 1, fig. 8. Upper Cretaceous, Texas. New name for: *Epistomina caracolla auctorum* (non Roemer, 1841). (Note: see list of synonyms in original paper.)

Eponides abatissae (Selli, 1944) var. *multicameratus* Petters and Gandolfi, Riv. Ital. Paleont. e Stratigr., vol. 54, fasc. 3, p. 7, pl. 1, fig. 3. Oligocene, Italy. (Note: The varietal name is preoccupied by *Eponides multicameratus* Kleinpell, 1938, Mioc. of California, Am. Assoc. Petroleum Geologists, Tulsa, p. 320, pl. 19, figs. 2, 3, 7. Upper Miocene, California. V. Petters has been informed by letter, dated March 22, 1949, about this homonym).

——— *dorsopustulatus* Dorreen, Jour. Paleontology, vol. 22, p. 295, pl. 39, fig. 2. Upper Eocene, New Zealand.

——— *ecuadorana* Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 64, pl. 10, fig. 16. Miocene, Ecuador.

——— *gratiosus* Cushman and Bermudez, *ibid.*, vol. 24, pl. 11, fig. 14. Paleocene, Cuba.

——— *labiomargus* Shifflett, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 3, p. 67, pl. 4, figs. 3, 4. Lower Eocene (Wilcox), Virginia.

——— *lunata* Brotzen, Sverig. geol. Unders.,

Ser. C., No. 493, Arsbok 42, no. 2, p. 77, pl. 10, figs. 17, 18. Paleocene, Sweden.

——— *minutissimus* Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 5, pl. 1, fig. 13. Lower Oligocene, Mississippi.

——— *plummerae* Cushman, *ibid.*, vol. 24, p. 44, pl. 8, fig. 9. Paleocene, Texas. For: *Truncatulina tenera* Plummer, 1927, (non Brady, 1884), Univ. Texas Bull. 2644, p. 146, pl. 9, fig. 5; for: *Eponides cf. tenera* Kline, 1943, Miss. State Geol. Surv., Bull. 53, p. 53, pl. 5, figs. 16–18; for: *Eponides cf. haidingeri* Cushman and Todd, 1946, (non d'Orbigny, 1846), Cushman Lab. Foram. Res., Contr., vol. 22, p. 62, pl. 11, figs. 5, 6; and for: *Eponides sp.* Cushman, 1940, *ibid.*, vol. 16, p. 71, pl. 12, fig. 8.

——— *tethycus* Dorreen, Jour. Paleontology, vol. 22, p. 295, pl. 39, fig. 3. Upper Eocene, New Zealand.

——— *toulmini* Brotzen, Sver. geol. Unders., Ser. C, No. 493, Arsbok 42, no. 2, p. 78, pl. 10, fig. 16. Paleocene, Sweden. For: *Eponides boueana* Toulmin, 1941, (non d'Orbigny, 1846), Jour. Paleontology, vol. 15, p. 601, pl. 81, figs. 6, 7.

Eulepidina, see *Lepidocyclina*

FALSOPALMULA gen. nov. Bartenstein, Senckenbergiana, vol. 28, p. 124. Family Lagenidae; subfamily Nodosariinae. Genotype: *Flabellina tenuistriata* Franke, 1936, Preuss. geol. Landesanstalt, Abhandl., new series, No. 169, p. 93, pl. 9, fig. 17. Jurassic (Liassic and Dogger), Upper Cretaceous (Senonian).

Flabellinella duestensis Bartenstein, Erdöl und Kohle, vol. 1, p. 184, text fig. 13. Lower Hauterivian, Germany.

——— *hannoverana* Bartenstein, *ibid.*, vol. 1, p. 184, text fig. 14. Middle Barremian, Germany.

Flabellina see *Palmula*.

Flintina novozealandica Dorreen, Jour. Paleontology, vol. 22, p. 287, pl. 36, fig. 8. Upper Eocene, New Zealand.

Fusulina ? insolita Thompson, Univ. Kansas Paleont. Contr., Protozoa, Art. 1, p. 96, pl. 32, fig. 7; pl. 38, figs. 9–13. Middle Pennsylvanian, N. Mexico.

Fusulinella devexa Thompson, *ibid.*, Protozoa, Art. 1, p. 94, pl. 32, figs. 6, 10; pl. 35, figs. 1–15; pl. 36, figs. 7–10, 12–17. Middle Pennsylvanian, New Mexico.

——— *famula* Thompson, *ibid.*, Protozoa, Art. 1, p. 91, pl. 32, figs. 4, 5; pl. 38, figs. 1–8. Middle Pennsylvanian, N. Mexico.

——— *fugax* Thompson, *ibid.*, Protozoa, Art. 1, p. 88, pl. 32, fig. 2; pl. 33, figs. 1–8. Middle Pennsylvanian, N. Mexico.

——— *juncea* Thompson, *ibid.* Protozoa, Art. 1, p. 93, pl. 1, fig. 3; pl. 32, fig. 1; pl. 37, figs. 1–18. Middle Pennsylvanian, N. Mexico.

——— *proxima* Thompson, *ibid.*, Protozoa, Art. 1, p 90, pl. 23, figs. 9–20. Middle Pennsylvanian, New Mexico.

Gaudryina almadenensis Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 92, pl. 16, fig. 5. Cretaceous (?), California.

——— *exilis* Cushman and Brönnimann, *ibid.*, vol. 24, p. 40, pl. 7, figs. 15, 16. Recent, Gulf of Paria, Trinidad, B.W.I., 0–2 fathoms.

——— *pseudocollinsi* Cushman and Stainforth, 1945, var. *primitiva* Cushman and H. H. Renz, Cushman Lab. Foram. Res., Spec. Publ. No. 24, p. 13, pl. 3, figs. 1, 2. Upper Eocene, Trinidad, B.W.I.

Gavelinella lellingensis Brotzen, Sver. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 75, pl. 11, figs. 1, 2; text fig. 20, nos. 1–3. Paleocene, Sweden.

GLABRATELLA gen. nov. Dorreen, Jour. Paleontology, vol. 22, p. 294. Family Rotallidae; subfamily Discorbisinae. Genotype: *Glabratella crassa* Dorreen, 1948, *ut infra*. Upper Eocene; Miocene, Pliocene, Recent.

——— *crassa* Dorreen, *ibid.*, vol. 22, p. 294, pl. 39, fig. 1. Upper Eocene, New Zealand.

Globigerina almadenensis Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 95, pl. 16, figs. 18, 19. Cretaceous (?, probably lower), California.

——— *portsdownensis* Williams-Mitchell, Geologists' Assc. London, Proc., vol. 59, p. 96, pl. 8, fig. 4. Cenomanian, England.

GLOBIGERINELLOIDES gen. nov. Cushman and ten Dam, Cushman Lab. Foram. Res., Contr., vol. 24, p. 42. Family Globigerinidae. Genotype: *Globigerinelloides algeriana* Cushman and ten Dam, *ut infra*. Upper Cretaceous.

——— *algeriana* Cushman and ten Dam, *ibid.*, vol. 24, p. 43, pl. 8, figs. 4–6. Upper Cretaceous, western Algeria.

Globorotalia almadenensis Cushman and Todd, *ibid.*, vol. 24, p. 98, pl. 16, fig. 24. Cretaceous ?, (probably lower), California.

——— *californica* Cushman and Todd, *ibid.*, vol. 24, p. 96, pl. 16, figs. 22, 23. Cretaceous ?, (probably lower). California.

——— *chaldonensis* Williams-Mitchell, Geologists' Assoc. London, Proc., vol. 59, p. 99, pl. 9, fig 8 Turonian, England. For: *Globorotalia micheliniana* Cushman, 1931, (non d'Orbigny, 1840, *Rotalina*), Cushman Lab. For. Res., Contr., vol. 7, p. 45, pl. 6, fig. 8.

——— *decorata* Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 97, pl. 16, fig. 21. Cretaceous ?, (probably lower), California.

——— *lobata* Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, no. 2, p. 91, pl. 17, fig. 3. Paleocene, Sweden.

Globotruncana benacensis Cita, Riv. Ital. Paleont. e Strat., vol. 54, p. 147, pl. 3, fig. 3. Cenomanian-Turonian, Italy.

Globulina arenacea Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, no. 2, p. 48, text fig. 10, Nr. 3. Paleocene, Sweden.

GUBLERINA gen. nov. Kikoine, Soc. géol. France, Bull., (5), vol. 18, p. 26. Heterohelicidae. Genotype: *Gublerina cuvillieri* Kikoine, 1948, *ut infra*. Maestrichtian.

——— *cuvillieri* Kikoine, *ibid.*, (5), vol. 18, p. 26, pl. 2, fig. 10. Upper Cretaceous (Maestrichtian), France.

Gümbelina striata (Ehrenberg, 1854), var. *deformis* Kikoine, *ibid.*, (5), vol. 18, p. 20, pl. 1, fig. 8. Upper Cretaceous (Maestrichtian), France.

Guttulina elegans Dorsey, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 292, pl. 32, figs. 4, 5. Miocene, Maryland. For: *Guttulina austriaca* Cushman and Ponton, 1932, (non d'Orbigny, 1846), Florida State Geol. Surv., Bull. 9, p. 65, pl. 9, figs. 13, 14; and for same species in Ellisor, 1940, Amer. Assoc. Petroleum Geologists, Bull., vol. 24, no. 3, pl. 5, figs. 7, 8.

——— *problema* d'Orbigny, 1826, var. *costata* Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 49. (Described but not figured.) Paleocene, Sweden.

——— *rectiornata* Dorsey, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 293, pl. 32, figs. 1, 2. Miocene, Maryland. For: *Guttulina costatula* Cushman, 1930, (non Galloway and Wissler, 1927), Florida State Geol. Surv., Bull. 4, p. 33, pl. 5, fig. 15; and for same species in Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Pap. 175-A, p. 17, pl. 6, fig. 1.

Gyroidina madrugaensis Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24, p. 85, pl. 14, figs. 10–12. Paleocene, Cuba.

——— *marylandica* Cushman, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 224, pl. 15, figs. 19, 20. Miocene (probably reworked from Eocene), Maryland.

Gyroidinoides pontoni Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, no. 2, p. 76, pl. 11, figs. 4, 5. Paleocene, Sweden.

——— *venezuelana* H. H. Renz, Geol. Soc. America Mem. no. 32, p. 141, pl. 12, fig. 21. Lowermost Miocene, Falcon, Venezuela.

Haplophragmium salsum Cushman and Bronnimann, Cushman Lab. Foram. Res., Contr., vol. 24, p. 16, pl. 3, figs. 10–13. Recent, west coast of Trinidad, B.W.I., brackish water.

Hauerina notoensis Dorreen, Jour. Paleontology, vol. 22, p. 287, pl. 36, fig. 9. Upper Eocene, New Zealand.

HAURANIA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 11. Family Lituolidae; subfamily Lituolinae. Genotype: *Haurania deserta* Henson, 1948, *ut infra*, Jurassic (or ? Triassic).

——— *amiji* Henson, *ibid.*, p. 12, pl. 15, figs. 5–10. Jurassic (or Triassic,) Iraq.

——— *deserta* Henson, *ibid.*, p. 12, pl. 15, figs. 1–4. Jurassic (or Triassic), Iraq.

HÖGLUNDINA gen. nov. Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 92. Family Epistominidae. Genotype (given by Brotzen): *Rotalia elegans* d'Orbigny. Liassic to Recent. (Note: Brotzen does not indicate an exact reference to the figure of the genotype. In our opinion it is certainly not *Rotalia* (*Turbinoline*) *elegans* d'Orbigny, 1826, figured from the "Planches Inédites" of d'Orbigny by Fornasini, 1906, Accad. Sci. Bologna, Mem., vol. 8, pl. 3, fig. 10, but rather the figure No. 142 given by Parker, Jones, and Brady, 1871, Ann. Mag. Nat. Hist., (4), vol. 8, pl. 12, fig. 142, which is a reproduction of *Hammoniformis trochiformis* Soldani, 1789–1799, Testaceogr., Appendix, pl. 2, fig. R, on which d'Orbigny in 1826 based his *Rotalia* (*Turbinuline*) *elegans*.

Hopkinsina hancocki Todd, in Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 276, pl. 35, fig. 1. Recent, Pacific, off Galapagos Islands, 35–68 fathoms.

——— *oceanica* Todd, in Cushman and McCulloch, *ibid.*, vol. 6, no. 5, p. 276, pl. 35, fig. 2. Recent, Pacific, off coast of Colombia, 58 fathoms.

IRAQIA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., Family Orbitolinidae. Genotype: *Iraqia simplex* Henson, 1948, *ut infra*. Lower to Middle Cretaceous.

——— *simplex* Henson, *ibid.*, p. 70, pl. 1, figs. 1–3. Lower Cretaceous. Iraq.

Karreriella washingtonensis Rau, Jour. Paleontology, vol. 22, p. 158, pl. 27, figs. 5, 6. Upper Eocene, Washington.

Labrospira columbiensis (Cushman, 1925, var. *robusta* Cushman and McCulloch, *nom. nov.*, Cushman Lab. Foram. Res., Contr., vol. 24, p. 76. Recent. Pacific. New name for: *Haplophragmoides columbiensis* Cushman 1925, var. *evolutum* Cushman and McCulloch, 1939, (non Natland, 1938), Allan Hancock Pacific Exped., vol. 6, no. 1, p. 73, pl. 5, figs. 11, 12; pl. 6, figs. 1, 2.

——— *salsa* Cushman and Bronnimann, *ibid.*, vol. 24, p. 16, pl. 3, figs. 5, 6. Recent, west coast of Trinidad, B.W.I., brackish water.

Lagena lisbonensis Cushman and Todd, *ibid.*, vol. 24, p. 30, pl. 5, fig. 22. Eocene, Mississippi. For: *Lagena costata* (Williamson, 1858) var. *amphora* Howe, 1939, (non Reuss, 1863), Louisiana Geol. Surv., Bull. 14, p. 49, pl. 6, fig. 15.

——— *mississippiensis* Cushman and Todd, *ibid.*, vol. 24, p. 30, pl. 5, fig. 24. Eocene, Mississippi.

Lagunculina vadescens Cushman and Bronnimann, *ibid.*, vol. 24, p. 15, pl. 3, figs. 1, 2. Recent, west coast of Trinidad, B.W.I., brackish water.

Lamarckina novozealandica Dorreen, Jour. Paleontology, vol. 22, p. 297, pl. 40, fig. 1. Upper Eocene, New Zealand.

——— *paleocenica* Cushman, Cushman Lab. Foram. Res., Contr., vol. 24, p. 44, pl. 8, fig. 8. Paleocene, Tennessee.

——— *turgida* Dorreen, Jour. Paleontology, vol. 22, p. 297, pl. 39, fig. 6. Upper Eocene, New Zealand.

Leptodermella excentrica Cushman and Bronnimann, Cushman Lab. Foram. Res., Contr., vol. 24, p. 37, pl. 7, figs. 1, 2. Recent, Gulf of Paria, Trinidad, B.W.I., 0–2 fathoms.

——— *salsa* Cushman and Bronnimann, *ibid.*,

vol. 24, p. 15, pl. 3, figs. 3, 4. Recent, west coast of Trinidad, B.W.I., brackish water.

LITUONELLOIDES gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 26. Family Orbitolinidae. Genotype: *Lituonelloides compressus* Henson, 1948, *ut infra*. Upper Cretaceous.

——— *compressus* Henson, *ibid.*, p. 27, pl. 6, fig. 1; text fig. 2 a-c. Maestrichtian, Arabia.

Lituotuba eocenica Cushman and H. H. Renz, Cushman Lab. Foram. Res., Spec. Publ. 24 p. 7, pl. 1, figs. 20, 21. Eocene, Trinidad, B.W.I.

Loftusia coxi Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 21, pl. 9, figs. 6, 8. Maestrichtian, Arabia.

MANGASHTIA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 94. Family Meandropsinidae. Genotype: *Mangashtia viennoti* Henson, 1948, *ut infra*. Middle Cretaceous.

——— *viennoti* Henson, *ibid.*, p. 94, pl. 12, figs. 61–21. Cenomanian-Turonian, Iran.

MANORELLA gen. nov. Grice, Jour. Paleontology, vol. 22, p. 223 Family Placopsilinidae; subfamily Polyphragminae. Genotype: *Manorella proteus* Grice, 1948, *ut infra*, Upper Cretaceous.

——— *proteus* Grice, *ibid.*, vol. 22, p. 223, text figs. 1–5. Upper Cretaceous (Austin Chalk), Texas.

Marginulina distincta Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24, p. 69, pl. 11, fig. 2. Paleocene, Cuba.

Meandropsina vidali Schlumberger, 1898, var. *biconcava* Henson, Larger Imperforate Foraminifera S.-W. Asia, Brit. Mus. Nat. Hist., p. 82, pl. 8.

MEANDROPSINIDAE fam. nov. Henson, *ibid.*, p. 77. Middle Cretaceous to Eocene; ? Miocene. This new family includes the following genera: *Broeckina* Munier-Chalmas, 1882; *Broeckinella* Henson, 1948, *ut supra; Cyclolina* d'Orbigny, 1846; *Cyclopsinella* Galloway, 1933; *Dohaia* Henson, 1948, *ut supra; Edomia* Henson, 1948, *ut supra; Fallotia* H. Douvillé, 1902; *Mangashtia* Henson, 1948, *ut supra; Meandropsina* Munier-Chalmas, 1899; *Orbitolinella* Henson, 1948, *ut infra; Praesorites* H. Douvillé, 1902; *Pseudedomia* Henson, 1948, *ut infra; Pseudorbitolina* H. Douvillé, 1910; *Qataria* Henson, 1948, *ut infra; Rhapydionina* Stache, 1912; *Rhipidionina* Stache, 1912; *Saudia* Henson, 1948, *ut infra; Taberina* Keijzer, 1945; and *Zekritia* Henson, 1948, *ut infra*.

Miliolinella robusta Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 2, pl. 1, fig. 3. Lower Oligocene, Mississippi.

NEOFLABELLINA nom. nov. Bartenstein, Senckenbergiana, vol. 28, p. 122, footnote. Family Lagenidae; subfamily Nodosariinae. Genotype: *Flabellina rugosa* d'Orbigny, 1840, Soc. géol. France, Mém., vol. 4, p. 23, pl. 2, figs. 4, 5, 7. New name for: *Flabellina* d'Orbigny, 1839 (non *Flabellina* F. S. Voigt, 1834, Mollusca). Upper Cretaceous.

NEOSCHWAGERINIDAE fam. nov. Dunbar, in Cushman, Foraminifera, their classification etc., 4th edition, pp. 164–170. Permian. This new family comprises the subfamily Verbeekininae with *Brevaxina* Schenck and Thompson, 1940, *Eoverbeekina* Lee, 1933, *Misellina* Schenck and Thompson, 1940. *Pseudodoliolina* Yabe and Hanzawa, 1932, and *Verbeekina* Staff, 1909; and the subfamily Neoschwagerininae with *Cancellina* Hayden, 1909, *Colania* Lee, 1933, *Lepidolina* Lee, 1933, *Neoschwagerina* Yabe, 1903, *Sumatrina* Volz, 1904, and *Yabeina* Deprat, 1914.

Nodobaculariella scita Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 2, pl. 1, fig. 5. Lower Oligocene, Mississippi.

Nodosaria loeblichae ten Dam, *nom. nov.*, Jour. Paleontology, vol. 22, p. 181. Neocomian, Holland. New name for: *Nodosaria rugosa* ten Dam, 1946, (non d'Orbigny, 1939), Jour. Paleontology, vol. 20, p. 575, pl. 88, fig. 7.

Nonion agrestum Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 53, pl. 9, fig. 14. Miocene, Ecuador.

——— *marylandicum* Dorsey, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 301, pl. 35, fig. 2. Miocene, Maryland.

——— *obducum* Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 53, pl. 9, fig. 13. Miocene, Ecuador.

——— *tisburyensis* Butcher, *ibid.*, vol. 24, p. 22, text figs. 1–3. Recent, brackish tidal ponds, Cape Cod, Massachusetts.

Nonionella ecuadorana Cushman and Stevenson, *ibid.*, vol. 24, p. 54, pl. 9, fig. 15. Miocene, Ecuador.

——— *ovata* Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 68, pl. 10, figs. 13, 14. Paleocene, Sweden.

Notorotalia tainuia Dorreen, Jour. Paleontology, vol. 22, p. 290, pl. 37, fig. 13. Upper Eocene, New Zealand.

Nubecularia triloculina ten Dam, Jour. Paleontology, vol. 22, p. 178. Not described and not figured. Middle Neocomian, Holland. For: *Nubecularia lucifuga* Jones and Parker, 1860 (non Defrance, 1825), Geol. Soc. London, Quart. Jour., vol. 16, p. 455, pl. 20, figs. 52–56.

Nummulites (*Nummulites*) *aster* de Cizancourt, Soc. géol. France, Mém., new ser., vol. 27, fasc. 1, No. 57, p. 23. (not figured). Eocene, Barbados. For: *Operculinoides catenula* Barker, 1939, (non Cushman and Jarvis, 1932), U. S. Nat. Mus., Proc., vol. 86, pl. 14, fig. 8.

——— (———) *barbadica* de Cizancourt, *ibid.*, Mém. No. 57, p. 21, pl. 1, fig. 18; pl. 2, figs. 5–7. Eocene, Barbados.

——— (———) *convexa* de Cizancourt, *ibid.*, Mém. No. 57, p. 21, pl. 1, fig. 19, pl. 2, figs. 8–13. Eocene, Barbados.

——— (———) *scotlandica* de Cizancourt, *ibid.*, Mém. No. 57, p. 22, pl. 2, figs. 1–3. Eocene, Barbados.

——— (———) *senni* de Cizancourt, *ibid.*, Mém. No. 57, p. 19, pl. 1, figs. 13–17. Paleocene and Eocene, Barbados.

——— (*Operculinoides*) *torifera* de Cizancourt, *ibid.*, Mém. No. 57, p. 29, pl. 1, figs. 6–8. Eocene, Barbados.

NUMMULITELLA gen. nov. Dorreen, Jour. Paleontology, vol. 22, p. 291, Family Nummulitidae, Genotype: *Nummulitella polystylata* Dorreen, 1948, *ut infra*. Upper Eocene.

——— *polystylata* Dorreen, *ibid.*, vol. 22, p. 291, pl. 38, fig. 1. Upper Eocene, New Zealand.

Operculinoides see *Nummulites*.

Orbitolina concava (Lamarck, 1801) var. *qatarica* Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 66, pl. 5, figs. 7–11. Lower Cenomanian, Arabia.

——— ——— (———) var. *sefini* Henson, *ibid.*, p. 64, pl. 5, figs. 1–4, 6. Cenomanian, Iraq.

——— *discoidea* Gras, 1852, var. *delicata* Henson, *ibid.*, p. 54, pl. 1, fig. 4; pl. 2, figs. 13, 14. ? Barremian, Arabia.

——— ——— ——— var. *libanica* Henson, *ibid.*, p. 55, pl. 2, figs. 10, 12. Aptian, Lebanon.

——— *kurdica* Henson, *ibid.*, p. 48, pl. 1, figs. 9–15. Lower Cretaceous, Iraq.

ORBITOLINELLA gen. nov. Henson, *ibid.*, p. 90. Family Meandropsinidae. Genotype: *Orbitolinella depressa* Henson, 1948, *ut infra*, Middle Cretaceous (Cenomanian-Turonian).

——— *depressa* Henson, *ibid.*, p. 92, pl. 6, figs. 12–15. Cenomanian-Turonian, Arabia.

Palmula primitiva Cushman, 1939, var. *paleocenica* Cushman, Cushman Lab. Foram. Res., Contr., vol. 24, p. 43, pl. 8, fig. 7. Paleocene, Alabama. For: *Palmula cf. primitiva* Cushman, 1940, *ibid.*, vol. 16, p. 62, pl. 9, fig. 33; and for: *Palmula cf. primitiva* Cushman in Kline, 1943, Miss. State Geol. Surv., Bull. 53, p. 35, pl. 3, fig. 10.

——— (*Flabellina*) *robusta* Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 45, pl. 8, figs. 4, 5; text fig. 9. Paleocene, Sweden.

Parrella algeriana Cushman and ten Dam, Cushman Lab. Foram. Res., Contr., vol. 24, p. 49, pl. 9, figs. 1, 2. Upper Eocene, western Algeria.

——— *incisa* Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 104, footnote 1, text fig. 28-B. Cenomanian, Denmark.

Pelosina dubia Cushman and H. H. Renz, Cushman Lab. Foram. Res. Spec. Publ. 24, p. 5, pl. 1, fig. 7. Eocene, Trinidad, B.W.I.

Peneroplis maui Dorreen, Jour. Paleontology, vol. 22, p. 291, pl. 38, fig. 2. Upper Eocene, New Zealand.

Planomalina ? almadenensii Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 98, pl. 16, fig. 25. Cretaceous ?, probably lower, California.

Planularia charapotoa Cushman and Stevenson, *ibid.*, vol. 24, p. 52, pl. 9, fig. 9. Miocene, Ecuador.

——— *ecuadorana* Cushman and Stevenson, *ibid.*, vol. 24, p. 52, pl. 19, figs. 7, 8. Miocene, Ecuador.

Planulina charapotoensis Cushman and Stevenson, *ibid.*, vol. 24, p. 67, pl. 10, fig. 28, Miocene, Ecuador.

——— *ecuadorana* Cushman and Stevenson, *ibid.*, vol. 24, p. 67, pl. 10, fig. 29, Miocene, Ecuador.

——— *gardesana* Cita, Riv. Ital. di Paleont. e Strat., vol. 54, p. 132, pl. 2, fig. 4, Upper Cretaceous, Northern Italy.

——— *limbata* Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 85, pl. 13, pl. 13, fig. 7. Paleocene Sweden. (Note: This species name is preoccupied by Natland, 1938, Bull. Scripps Inst. Oceanogr., Techn. Ser., vol. 4, No. 5, p. 151, pl. 7, figs. 4, 5. Recent, Pacific, and has subsequently been changed in October 1948 by Brotzen to *Planulina scanica nom. nov. ut infra.*)

——— *scanica* Brotzen, *nom. nov.*, The Micropaleontologist, vol. 2, No. 4, p. 13. Paleocene, Sweden. New name for: *Planulina limbata* Brotzen, 1948 (non Natland, 1938) *ut supra.*

Plectina trinitatensis Cushman and H. H. Renz, Cushman Lab. Foram. Res., Spec. Publ., 24, p. 15, pl. 3, fig. 12. Eocene, Trinidad, B.W.I.

PNINAELLA gen. nov. Brotzen, Sverig. geol. Unders., Ser. C, No. 493. Arsbok 42, No. 2, p. 119. Family: Epistominidae (?), Genotype: *Pninaella scanica* Brotzen, 1948, *ut infra*. Paleocene, Pliocene, Recent.

——— *scanica* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 120, pl. 15, figs. 5, 6. Paleocene, Sweden.

Profusulinella apodacensis Thompson, Univ. Kansas Paleont. Contr., Protozoa, Art. 1, p. 85, pl. 27, figs. 9, 10; pl. 31, figs. 10–17. Middle Pennsylvanian, New Mexico.

——— *copiosa* Thompson, *ibid.*, Art. 1, p. 80, pl. 27, figs. 1–3; pl. 28, figs. 14–32. Lower Middle Pennsylvanian, Texas.

——— *decora* Thompson, *ibid.*, Art. 1, p. 83, pl. 27, figs. 5, 6, 12; pl. 29, figs. 5–30. Lower Middle Pennsylvanian, Texas.

——— *munda* Thompson, *ibid.*, Art. 1, p. 82, pl. 27, fig. 4; pl. 30, figs. 1–7. Lower Middle Pennsylvanian, Texas.

——— *regia* Thompson, *ibid.*, Art. 1, p. 83, pl. 1, fig. 1; pl. 27, figs. 7, 8, 13; pl. 30, figs. 8–19. Lower Middle Pennsylvanian, Texas.

——— *spicata* Thompson, *ibid.*, Art. 1, p. 86, pl. 27, fig. 11; pl. 31, figs. 1–9. Middle Pennsylvanian, New Mexico.

Proteonina hancocki Cushman and McCulloch, *nom. nov.*, Cushman Lab. Foram. Res., Contr., vol. 24, p. 76. Recent, Pacific. New name for: *Proteonina compressa* Cushman and McCulloch, 1939 (non Paalzow, 1932), Allan Hancock Pacific Exped., vol. 6, no. 1, p. 42, pl. 1, fig. 10.

PSEUDEDOMIA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 95. Family Meandropsinidae. Genotype: *Pseudedomia multistriata* Henson, 1948, *ut infra*. Upper Cretaceous.

——— *multistriata* Henson, *ibid.*, p. 96, pl. 11, figs. 1, 2. Maestrichtian, Arabia.

Pseudoclavulina almadenensis Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol.

24, p. 93, p. 16, fig. 7. Cretaceous ?, probably lower, California.

——— *californica* Cushman and Todd, *ibid.*, vol. 24, p. 92, pl. 16, fig. 6. Cretaceous ?, probably lower, California.

——— *coria* Cushman and Todd, *ibid.*, vol. 24, p. 93, pl. 16, fig. 8. Cretaceous ?, probably lower, California.

——— *curta* Cushman and Bronnimann, *ibid.*, vol. 24, p. 41, pl. 7, figs. 19, 20. Recent, Gulf of Paria, Trinidad, B.W.I., 0–2 fathoms.

——— *gracilis* Cushman and Bronnimann, *ibid.*, vol. 24, p. 40, pl. 7, figs. 17, 18. Recent, Gulf of Paria, Trinidad, B.W.I., 0–2 fathoms.

——— *trinitatensis* Cushman and H. H. Renz, *ibid.*, Spec. Publ. 24, p. 13, pl. 3, fig. 5. Eocene, Trinidad, B.W.I.

Pseudocyclammina kelleri Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 16, pl. 9, figs. 4, 5. 7. Middle Jurassic, Iraq.

Pseudoglandulina madrugaensis Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24, p. 70, pl. 11, fig. 7. Paleocene, Cuba.

PSEUDOPARRELLA nom. nov. Cushman and ten Dam, *ibid.*, vol. 24, p. 49. Family Cassidulinidae. Genotype: *Pulvinulinella subperuviana* Cushman, 1926, *ibid.*, vol. 2, p. 63, pl. 9, fig. 9. New generic name for: *Pulvinulinella* Cushman, 1926 (non Eimer and Ficker, 1899), Cushman Lab. Foram. Res., Contr., vol. 2, p. 62.

——— *madrugaensis* Cushman and Bermudez, *ibid.*, Contr. vol. 24, p. 73, pl. 12, figs. 11–13. Paleocene, Cuba.

Pseudopolymorphina calvertensis Cushman, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 218, pl. 15, figs. 5–7. Miocene, Maryland.

——— *eichenbergi* ten Dam, Jour. Paleontology, vol. 22, p. 186, pl. 32, fig. 22. Neocomian, Holland. For: *Polymorphina aff. porrecta* Eichenberg, 1935, (non Reuss, 1860), Niedersächs. geol. Ver., 26. Jahresber., p. 183, pl. 17, fig. 4.

——— *geijeri* Brotzen, Sverig. geol. Unders. Ser. C, No. 493, Arsbok 42, No. 2, p. 52, text figs. 10, No. 15; 12, nos. 1–4. Paleocene, Sweden.

——— ——— ——— var. *angusta* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 53, text figs. 10, No. 14; 13, nos. 1–5. Paleocene, Sweden.

——— *paleocenica* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 50, text figs. 10, no. 13; 11, nos. 1–22. Paleocene, Sweden.

Pullenia charapotoensis Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 66, pl. 10, fig. 18. Miocene, Ecuador.

PULSIPHONINA subgen. nov. Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 106. New subgenus of genus *Siphonina* Reuss, 1850. Family Epistominidae. Subgenotype: *Siphonina prima*, Plummer, 1926 (1927), Univ. Texas Bull. 2644, p. 148, pl. 12, fig. 4. Maestrichtian to Paleocene, Eocene ?.

——— *elegans* Brotzen, *ibid.*, Arsbok 42, No. 2, p. 107, pl. 17, fig. 5. Paleocene, Sweden. (Note: The correct citation would be: *Siphonina* (*Pulsiphonina*) *elegans* Brotzen n. sp.)

Pulvinulinella atlantisae Cushman, 1939, var. *dissonata* Cushman and H. H. Renz, Cushman Lab. Foram. Res., Spec. Publ. 24, p. 35, pl. 7, figs. 11, 12. Eocene, Trinidad, B.W.I.

Pyramidina crassa Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, no. 2, p. 63, pl. 6, fig. 8. Paleocene, Sweden.

Pyrgo lupheri Rau, Jour. Paleontology, vol. 22, p. 160, pl. 28, figs. 8, 9. Upper Eocene, Washington.

QATARIA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 98. Family Meandropsinidae. Genotype: *Qataria dukhani* Henson, 1948, *ut infra.* Middle Cretaceous (upper Cenomanian to Turonian).

——— *dukhani* Henson, *ibid.* p. 100, pl. 7, figs. 11, 13; pl. 11, figs. 11–13; text fig. 15. Upper Cenomanian-Turonian, Arabia.

Quinqueloculina imperialis Hanna and Hanna, 1924, var. *porterensis* Rau, Jour. Paleontology, vol. 22, p. 159, pl. 27, figs. 9–11. Upper Eocene, Washington.

——— *weaveri* Rau, *ibid.*, vol. 22, p. 159, pl. 28, figs. 1–3. Upper Eocene, Washington.

Rectogümbelina trinitatensis Cushman and H. H. Renz, Cushman Lab. Foram. Res., Spec. Publ. 24, p. 23, pl. 5, fig. 7. Eocene, Trinidad, B.W.I.

REINHOLDELLA gen. nov. Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 126. Family Ceratobuliminidae. Genotype: (Brotzen's reference) "*Asterigerina dreheri*, collection Geologische Stichting Haarlem No. F. 410, original of ten Dam and Reinhold's figure 1, 1941." (Note: the genotype apparently is *Discorbis dreheri* Bartenstein, 1937, Abhandl. Senckenberg. Naturf. Ges., vol. 439, p. 192, pl. 6, fig. 15; pl. 8, fig. 42; pl. 10, fig. 47.) Lower Liassic to lower Oolithic.

Reussella aequa Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 251, pl. 31, fig. 7. Recent, Pacific, off Mexico 16 fathoms. For: *Reussia spinulosa* Cushman and Kellett, 1929 (non Reuss, 1850), U. S. Nat. Mus., Proc., vol. 75, Art. 25, p. 9, pl. 3, fig. 10.

——— *finlayi* Dorreen, Jour. Paleontology, vol. 22, p. 292, pl. 38, fig. 4. Upper Eocene, New Zealand.

——— *pacifica* Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 251, pl. 31, fig. 6. Recent, Pacific, off Galapagos Islands, 9 fathoms.

——— see *Bulimina*.

Rhapydionina urensis Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 86, pl. 7, figs. 5 a–c, 7; pl. 8, figs. 19–21; pl. 16, figs. 1, 4, 22, ? 6. Lutetian, Iraq.

——— ——— ——— var. *minima* Henson, *ibid.*, p. 88, pl. 16, figs. 19–21. Lutetian, Iraq.

Rhipidionina macfadyeni Henson, *ibid.*, p. 90, pl. 16, figs. 8, 10, 13, 14, 17, ? 5 and 7. Lutetian, Iraq.

——— *williamsoni* Henson, *ibid.*, p. 88, pl. 16,

figs. 2, 3, 9, 11, 12, 15, 16, 18, 23. Upper Lutetian, Iraq.

Robulus chehalisensis Rau, Jour. Paleontology, vol. 22, p. 162, pl. 29, figs. 14, 15. Upper Eocene, Washington.

——— *discus* Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, no. 2, p. 42, pl. 7, figs. 3–5; text fig. 7. Paleocene, Sweden.

——— *klagshamnensis* Brotzen, *ibid.*, Arsbok 42, no. 2, p. 41, pl. 7, figs. 1, 2. Paleocene, Sweden. For: *Cristellaria w.f. clypeiformis* d'Orb. in v. Koenen, 1885, Abhandl. k. Ges. Göttingen, vol. 32, p. 108, pl. 5, fig. 14; and for: *Cristellaria osnabrugensis* v. Munst. in Franke, 1927, Danmarks geol. Unders., vol. 2, no. 46, p. 27, pl. 2, fig. 14.

——— *lincolnensis* Rau, Jour. Paleontology, vol. 22, p. 161, pl. 28, figs. 14, 15. Upper Eocene Washington.

——— *midwayensis* (Plummer, 1927) var. *virginianus* Shifflett, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 3, p. 48, pl. 1, figs. 15, 16. Lower Eocene (Wilcox), Virginia.

Rosalina koeneni Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, No. 2, p. 73, pl. 9, fig. 11. Paleocene, Sweden.

——— *ystadiensis* Brotzen, *ibid.*, Arsbok 42, no. 2, p. 72, pl. 9, fig. 9. Paleocene, Sweden.

Rotalia ecuadorana Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 65, pl. 10, fig. 17. Miocene, Ecuador. (*Cave: Rotalia equatoriana* LeRoy, 1941.)

Rotalipora cushmani (Morrow, 1934) var. *evoluta* Sigal, Rev. Inst. Franç. Pétrole et Ann. Comb. Liquides, vol. 3, p. 100, pl. 1, fig. 3; pl. 2, fig. 2. Lower Cenomanian, Algeria.

——— *globotruncanoides* Sigal, *ibid.*, vol. 3, p. 100, pl. 1, fig. 4; pl. 2, figs. 3–5. Middle Cenomanian, Algeria.

Saracenaria fragilis Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24, p. 3, pl. 1, fig. 17. Upper Eocene, Mississippi.

——— *kellumi* Dorreen, Jour. Paleontology, vol. 22, p. 289, pl. 37, fig. 4. Upper Eocene, New Zealand.

SAUDIA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 97. Family Meandropsinidae. Genotype: *Saudia discoidea* Henson, 1948, *ut infra*. Lower Eocene.

——— *discoidea* Henson, *ibid.*, p. 97, p. 12, figs. 1–5; text fig. 14. Lower Eocene, Arabia.

Sigmorphina marylandica Cushman, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 219, pl. 15, fig. 8. Miocene, Maryland.

——— *nevifera* Dorsey, *ibid.*, Bull. 3, p. 298, pl. 34, figs. 6, 7. Miocene, Maryland. For: *Pyrulina albatrossi* Cushman and Cahill, 1933, (non Cushman and Ozawa, 1930), U. S. Geol. Surv., Prof. Pap. 175-A, p. 18, pl. 6, fig. 5.

——— *soluta* Brotzen, Sverig. geol. Unders., Ser. C, No. 493, Arsbok 42, no. 2, p. 53, pl. 8, figs. 6–10; text fig. 10, no. 16. Paleocene, Sweden.

——— *undulata* Rau, Jour. Paleontology, vol. 22, p. 170, pl. 30, figs. 15, 16. Upper Eocene, Washington.

Siphonina (Pulsiphonina) elegans Brotzen, see *Pulsiphonina*.

Siphonodosaria frizzelli Rau, Jour. Paleontology, vol. 22, p. 171, pl. 30, fig. 10. Upper Eocene, Washington.

——— *serrata* Muraour, Soc. géol. France, Comptes-rendus, p. 251, text figs. A–C. Pliocene, Astian, Algeria.

Spiroplectammina exilis Dorsey, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 275, pl. 27, figs. 1, 2. Miocene, Maryland. For: *Spiroplectammina gracilis* Cushman and Cahill, 1933, (non v. Muenster, 1838), U. S. Geol. Surv., Prof. Pap. 175-A, p. 6, pl. 1, figs. 6, 7.

——— *plummerae* Cushman, *nom. nov.*, *ibid.*, Bull. 2, p. 226, pl. 16, fig. 2. Eocene, Maryland. For: *Textularia carinata* d'Orbigny, 1846, var. *expansa* Plummer, 1926 (1927), Univ. Texas Bull. 2644, p. 67, pl. 3, fig. 1.

——— *spinosa* Dorsey, *ibid.*, Bull. 2, p. 276, pl. 27, figs. 5, 6. Miocene, Maryland.

——— *trinitatensis* Cushman and H. H. Renz, Cushman Lab. Foram. Res., Spec. Publ. 24, p. 11, pl. 2, figs. 13, 14. Upper Eocene, Trinidad, B.W.I.

Spiroplectoides see *Bolivinopsis*.

Staffella depressa Thompson, Univ. Kansas Paleont. Contr., Protozoa, Art. 1, p. 77, pl. 25, figs. 1–6. Lower middle Pennsylvanian, Texas.

——— *powwowensis* Thompson, *ibid.*, Art. 1, p. 78, pl. 25, figs. 7–12. Lower middle Pennsylvanian, Texas.

Stichocibicides cerviculus Shifflett, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 3, p. 76, pl. 5, fig. 10. Lower Eocene, Wilcox, Virginia.

STOMATORBINA gen. nov. Dorreen, Jour. Paleontology, vol. 22, p. 295. Family Rotaliidae; subfamily Rotaliinae. Genotype: *Lamarckina torrei* Cushman and Bermudez, 1937. Cushman Lab. Foram. Res., Contr., vol. 13, p. 21, pl. 2, figs. 24–26. Upper Eocene.

Taberina bingistani Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 83, pl. 6, figs. 4–6. Middle Cretaceous, Iran.

Textularia aorangi Dorreen, Jour. Paleontology, vol. 22, p. 286, pl. 36, fig. 2. Upper Eocene, New Zealand,

——— *kattagatensis* Höglund, *nom. nov.* Cushman Lab. Foram. Res. Contr., vol. 24, p. 46. New name for: *Textularia gracillima* Höglund, 1947, (non Andreae, 1884), Zool. Bidr. Uppsala, vol. 26, p. 180, pl. 13, fig. 2; text fig. 156. Recent, North Sea.

——— *obliqua* Dorsey, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 279, pl. 28, figs. 6, 7. Miocene, Maryland.

——— *ultima-inflata* Dorsey, *ibid.*, Bull. 2, p. 279, pl. 28, fig. 8. Miocene, Maryland.

Textularia ? almadenensis Cushman and Todd, Cushman Lab. Foram. Res., Contr., vol. 24,

p. 91, pl. 16, fig. 4. Cretaceous ?, probably lower, California.

THALMANNINELLA gen. nov. Sigal, Rev. Inst. Franç. Pétrole et Ann. Combust. Liquides, vol. 3, p. 101. Family Globorotaliidae. Genotype: *Thalmanninella brotzeni* Sigal, 1948, *ut infra*. Upper Cretaceous.

——— *brotzeni* Sigal, *ibid.*, vol. 3, p. 102, pl. 1, fig. 5; pl. 2, figs. 6, 7. Middle Cenomanian, Algeria.

Thurammina (?) faerleensis Höglund *nom. nov.*, Cushman Lab. Foram. Res., Contr., vol. 24, p. 45. New name for: *Thurammina (?) sphaerica* Höglund, 1947, (non Ireland, 1939), Zool. Bidr. Uppsala, vol. 26, p. 54, pl. 4, figs. 22–26. Recent, North Sea.

Tritaxilina ? almadenensis Cushman and Todd, *ibid.*, vol. 24, p. 94, pl. 16, fig. 9. Cretaceous ?, probably lower, California.

Trochammina comprimata Cushman and Bronnimann, *ibid.*, vol. 24, p. 41, pl. 8, figs. 1–3. Recent, west coast of Trinidad, B.W.I., brackish water.

——— *laevigata* Cushman and Bronnimann, *ibid.*, vol. 24, p. 41, pl. 7, figs. 21, 22. Recent west coast of Trinidad, B.W.I., brackish water. For: *Trochammina globigeriniformis* Cushman and Parker, 1931, (non Parker and Jones, 1865), U. S. Nat. Mus., Proc., vol. 80, Art. 3, p. 6, pl. 2, fig. 4.

——— *pacifica* Cushman, 1925, var. *simplissima* Cushman and McCulloch *nom. nov.*, *ibid.*, vol. 24, p. 76. Recent, Pacific. New name for: *Trochammina pacifica* Cushman, 1925, var. *simplex* Cushman and McCulloch, 1939, (non Friedberg, 1902), Allan Hancock Pacific Exped., vol. 6, no. 1, p. 104, pl. 11, fig. 4.

——— *quadriloba* Höglund *nom. nov.*, *ibid.*, vol. 24, p. 46. New name for: *Trochammina pusilla* Höglund, 1947, (non Geinitz, 1848), Zool. Bidr. Uppsala, vol. 26, p. 201, pl. 17, fig. 4; text figs. 183, 184. Recent, North Sea.

TROCHAMMINITA gen. nov. Cushman and Bronnimann, *ibid.*, vol. 24, p. 17. Family Trochamminidae. Genotype: *Trochamminita irregularis* Cushman and Bronnimann, *ut infra*. Recent, Brackish water.

——— *irregularis* Cushman and Bronnimann, *ibid.*, vol. 24, p. 17, pl. 4, figs. 1–3. Recent, west coast of Trinidad, B.W.I., brackish water.

Uvigerina bortotara (Finlay, 1939) var. *costata* Dorreen, Jour. Paleontology, vol. 22, p. 293, pl. 38, fig. 5. Upper Eocene, New Zealand.

——— *calvertensis* Cushman, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 222, pl. 15, figs. 9–11. Miocene, Maryland.

——— *charapotoensis* Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 62, pl. 10, fig. 4. Miocene, Ecuador.

——— *directa* Dorsey, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 308, pl. 36, fig. 21. Miocene, Maryland. For: *Uvigerina cf. pigmea* d'Orb. in Cushman, 1930, Florida State Geol. Surv., Bull. 4, p. 49, pl. 9, fig. 5.

——— *excellens* Todd, in Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 258, pl. 33, fig. 2. Recent, Pacific, off Mexico, 183 fathoms. For: *Uvigerina sp.* Cushman and Gray, 1946, Cushman Lab. Foram. Res., Spec. Publ. 19, p. 37, pl. 6, fig. 15.

——— *exilis* Cushman, State of Maryland, Board of Nat. Resources, Dept. of Geol. etc., Bull. 2, p. 237, pl. 15, fig. 12. Eocene, Maryland.

——— *incilis* Todd, in Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 260, pl. 33, fig. 4. Recent, Pacific, off Mexico, 50 fathoms.

——— *marksi* Cushman and Stevenson, Cushman Lab. Foram. Res., Contr., vol. 24, p. 62, pl. 10, fig. 6. Miocene, Ecuador.

——— *montesanensis* Rau, Jour. Paleontology, vol. 22, p. 778, pl. 119, figs. 10, 11. Lower Miocene, Washington.

——— *peregrina* Cushman, 1923, var. *dirupta* Todd, in Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 5, p. 267, pl. 34, fig. 3. Recent, Pacific, off California, 490 fathoms.

Vaginulina semilaevis Cushman and Bermudez, Cushman Lab. Foram. Res., Contr., vol. 24, p. 70, pl. 11, fig. 6. Paleocene, Cuba.

Valvulammina nassauensis Applin and Jordan, 1945, var. *cubana* Cushman and Bermudez, *ibid.*, vol. 24, p. 68, pl. 11, fig. 1. Paleocene, Cuba.

Valvulineria ecuadorana Cushman and Stevenson, *ibid.*, vol. 24, p. 64, pl. 10, fig. 12. Miocene, Ecuador.

——— *extensa* Cushman and Bermudez, *ibid.*, vol. 24, pl. 12, figs. 7–9. Paleocene, Cuba.

——— *insueta* Cushman and Bermudez, *ibid.*, vol. 24, p. 85, pl. 14, figs. 7–9. Paleocene, Cuba.

——— *madrugaensis* Cushman and Bermudez, *ibid.*, vol. 24, p. 73, pl. 12, fig. 10. Paleocene, Cuba.

——— *ravni* Brotzen, Sverig. geol. Unders., Ser. C., No. 493, Arsbok 42, No. 2, p. 74, pl. 9, fig. 13. Paleocene, Sweden.

Virgulina sandegreni Brotzen, *ibid.*, Arsbok 42, No. 2, p. 65, pl. 9, fig. 2. Paleocene, Sweden.

——— *unca* Cushman and Todd, Cushman Lab. Foram. Res. Contr., vol. 24, p. 4, pl. 2, fig. 3. Upper Eocene, Mississippi.

——— *yazooensis* Cushman and Todd, *ibid.*, vol. 24, p. 3, pl. 2, fig. 4. Upper Eocene, Mississippi.

Webbinella arctica Cushman, Cushman Lab. Foram. Res., Spec. Publ. 23, p. 14, pl. 1, figs. 14, 15. Recent, Arctic, East coast Hudson Bay, 5–7 fathoms. For: *Webbinella hemisphaerica* Cushman, 1922, (non Jones, Parker and Brady, 1866), Contr. Canadian Biol., p. 138.

WETHEREDELLA gen. nov. Wood, Geologists' Assoc. London, Proc., vol. 59, p. 20. Family relationship not yet established (probably new family). Genotype: *Wetheredella silurica* Wood, 1948, *ut infra*. Silurian.

——— *silurica* Wood, *ibid.*, vol. 59, p. 20, pl. 3, fig. B; pl. 5, fig. B. Silurian, Wenlock, England.

ZEKRITIA gen. nov. Henson, Larger Imperforate Foram. S.-W. Asia, Brit. Mus. Nat. Hist., p. 95. Family Meandropsinidae. Genotype: *Zekritia langhami* Henson, 1948, *ut infra.* Middle Cretaceous.

——— *langhami* Henson, *ibid.*, p. 95, pl. 11, fig. 7. Middle Cretaceous, probably Turonian, Arabia.

FORMS WITH NOMENCLATURA APERTA

(The numbers in italic type refer to the publications in the preceding Bibliography for 1948)

Alabamina sp. Brotzen, *26*, p. 98, text fig. 25. Danian, Sweden.

Ammobaculites sp. Shifflett, *215*, p. 45, pl. 1, fig. 6. Lower Eocene, Virginia.

——— *sp.* Parker, *188*, pl. 1, fig. 6. Recent, Atlantic.

Amphimorphina sp. 9 Stainforth, *219*, p. 129, pl. 24, figs. 9–11. Upper Eocene, Ecuador.

Amphistegina sp. Dorreen, *85*, p. 298, pl. 40, fig. 6. Upper Eocene, New Zealand.

Angulogerina sp. 1 Parker, *188*, pl. 1, fig. 14. Recent, Atlantic.

——— *sp. 2* Parker, *188*, pl. 5, fig. 22. Recent, Atlantic.

Arenobulimina sp. Cushman and Todd, *66*, p. 93, pl. 16, fig. 10. Cretaceous ?, California.

Astacolus sp. a Renz, *202*, p. 116, pl. 4, fig. 22. Upper Oligocene, Venezuela.

——— *sp. b* Renz, *202*, p. 116, pl. 4, fig. 24. Middle Oligocene, Venezuela.

Bolivina sp. Cushman and Todd, *66*, p. 95, pl. 16, fig. 14. Cretaceous ?, California.

——— *sp.* Dorreen, *85*, p. 292, pl. 38, fig. 3. Upper Eocene, New Zealand.

——— *sp. 1* Parker, *188*, pl. 5, fig. 16. Recent, Atlantic.

——— *sp. 2* Parker, *188*, pl. 5, fig. 18. Recent, Atlantic.

Bulimina sp. Cushman and Todd, *66*, p. 94, pl. 16, fig. 13. Cretaceous ?, California.

——— *sp.* Dorsey, *86*, p. 304, pl. 35, fig. 4. Miocene, Maryland.

——— *sp.* Parker, *188*, pl. 5, fig. 13. Recent, Atlantic.

Cassidulina sp. Parker, *188*, pl. 6, fig. 6. Recent, Atlantic.

Cibicides sp. Dorsey, *86*, p. 316, pl. 39, fig. 3. Miocene, Maryland.

Conorbina sp. Brotzen, *26*, p. 71, pl. 9, fig. 8. Paleocene, Sweden.

Cyclammina sp. Shifflett, *215*, p. 45, pl. 1, fig. 7. Eocene, Virginia.

Cymbalopora sp. Brotzen, *26*, p. 91, pl. 15, fig. 1. Paleocene, Sweden.

Darbyella ? sp. Rau, *197*, p. 163, pl. 29, figs. 18, 19. Eocene, Washington.

Dentalina sp. Cushman, *45*, p. 45, pl. 5, fig. 7. Recent, Arctic.

——— *sp.* Cushman, *45*, p. 45, pl. 5, fig. 6. Recent, Arctic.

——— *sp. A* Cushman and Stevenson, *63*, p. 53, pl. 9, fig. 11. Miocene, Ecuador.

——— *sp. A* Cushman and Todd, *65*, p. 29, pl. 5, fig. 18. Eocene, Mississippi.

——— *sp. B* Cushman and Stevenson, *63*, p. 53, pl. 9, fig. 12. Miocene, Ecuador.

——— *sp. B* Cushman and Todd, *65*, p. 29, pl. 5, fig. 19. Eocene, Mississippi.

——— *sp.* Dorsey, *86*, p. 285, pl. 31, fig. 2. Miocene, Maryland.

——— *sp. A* Rau, *197*, p. 166, pl. 29, fig. 3. Eocene, Washington.

——— *? sp. B* Rau, *197*, p. 166, pl. 29, fig. 5. Eocene, Washington.

——— *sp. C* Rau, *197*, p. 167, pl. 29, fig. 7. Eocene, Washington.

——— *? sp. D* Rau, *197*, p. 167, pl. 29, fig. 8. Eocene, Washington.

Discocyclina (*Discocyclina*) *sp.* de Cizancourt, *36*, p. 55, pl. 8, fig. 19; pl. 9, fig. 24. Eocene, Czechoslovakia.

Discorbis sp. Dorsey, *86*, p. 311, pl. 37, fig. 3. Miocene, Maryland.

——— *sp. 2* Parker, *188*, pl. 1, fig. 15. Recent, Atlantic.

Ellipsonodosaria sp. Cushman, *49*, p. 239, pl. 19, fig. 11. Eocene, Maryland.

Elphidium sp. Parker, *188*, pl. 1, fig. 12. Recent, Atlantic.

——— *sp. A 5* Stainforth, *219*, p. 120, pl. 24, figs. 4, 5. Miocene, Ecuador.

——— *sp. B 6* Stainforth, *219*, p. 120, pl. 24, figs. 6, 7. Miocene, Ecuador.

Entosolenia ? sp. Renz, *202*, p. 133, pl. 6, fig. 17. Oligocene, Venezuela.

Eponides sp. Cushman and Todd, *66*, p. 95, pl. 16, fig. 15. Cretaceous ?, California.

——— *sp.* Parker, *188*, pl. 3, fig. 13. Recent, Atlantic.

——— *sp.* Shifflett, *215*, p. 68, pl. 4, fig. 7. Eocene, Virginia.

——— *? sp.* Rau, *198*, p. 779, pl. 119, figs. 18–20. Miocene, Washington.

Fusulinella sp. A Thompson, *227*, p. 96, pl. 36, figs. 1–6, 11. Pennsylvanian, Texas.

Gavelinella (?) sp. Brotzen, *26*, p. 76, pl. 9, fig. 10. Paleocene, Sweden.

Globigerina sp. Cushman and Todd, *66*, p. 96, pl. 16, fig. 17. Cretaceous ?, California.

——— *sp.* Dorsey, *86*, p. 313, pl. 38, fig. 4. Miocene, Maryland.

Globigerinoides sp. A Dorsey, *86*, p. 314, pl. 38, figs. 5–7. Miocene, Maryland.

——— *sp. B* Dorsey, *86*, p. 314, pl. 38, figs. 8, 9. Miocene, Maryland.

——— *sp. indet. 13* Stainforth, *219*, p. 123, pl. 26, figs. 13–15. Miocene, Ecuador.

Guttulina sps. Dorreen, *85*, p. 289, pl. 37, fig. 8. Eocene, New Zealand.

Gyroidina sp. Cushman and Todd, *66*, p. 95, pl. 16, fig. 16. Cretaceous ?, California.

Halkyardia sp. 1 Stainforth, *219*, p. 130, pl. 25, figs. 1, 2. Oligocene, Ecuador.

Hantkenina spp. Stainforth, *219*, p. 137, pl. 25, fig. 3. Eocene, Ecuador.

Haplophragmoides sp. Parker, *188*, pl. 4, fig. 20. Recent, Atlantic.

Hastigerinella sp. Cushman and Todd, *66*, p. 96, pl. 16, fig. 20. Cretaceous ?, California.
Lagena sp. Cushman and Todd, *65*, p. 30, pl. 5, fig. 25. Eocene, Mississippi.
——— *sp. A* Dorsey, *86*, p. 290, pl. 31, figs. 7, 8. Miocene, Maryland.
——— *sp. B* Dorsey, *86*, p. 290, pl. 31, figs. 13, 14. Miocene, Maryland.
——— *sp. C* Dorsey, *86*, p. 291, pl. 31, figs. 17, 18. Miocene, Maryland.
——— *sp. D* Dorsey, *86*, p. 291, pl. 31, figs. 19–23. Miocene, Maryland.
——— *sp. E* Dorsey, *86*, p. 291, pl. 31, fig. 24. Miocene, Maryland.
——— *sp.* Rau, *197*, p. 169, pl. 30, fig. 4. Eocene, Washington.
——— *sp.* Rau, *198*, p. 777, pl. 119, fig. 4. Miocene, Washington.
Lepidocyclina (*Eulepidina*) *sp.* Rutten, *206*, p. 171, text fig. 1. Miocene, Borneo.
Lituola sp. Henson, *123*, p. 9, pl. 10, fig. 1. Jurassic, Arabia.
Lockhartia sp. Rutten, *206*, p. 171, text fig. 3. Reworked in Miocene, Borneo.
Marginulina sp. A Dorsey, *86*, p. 285, pl. 30, fig. 9. Miocene, Maryland.
——— *sp. B* Dorsey, *86*, p. 285, pl. 30, fig. 10. Miocene, Maryland.
——— *sp. C* Dorsey, *86*, p. 285, pl. 30, fig. 11. Miocene, Maryland.
——— *sp. D* Dorsey, *86*, p. 285, pl. 30, figs. 12, 13. Miocene, Maryland.
Massilina sp. Parker, *188*, pl. 2, fig. 8. Recent, Atlantic.
Nankinella sp. Thompson, *227*, p. 77, pl. 25, figs. 13–16. Pennsylvanian, Texas.
Nodosaria sp. Shifflett, *215*, p. 51, pl. 2, fig. 6. Eocene, Maryland.
——— *? sp.* Rau, *197*, p. 168, pl. 30, fig. 6. Eocene, Washington.
Nummulites sp. de Cizancourt, *35*, p. 25, pl. 1, fig. 9. Eocene, Barbados.
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Orbitolinopsis sp. Henson, *123*, p. 68, pl. 2, fig. 11. Cretaceous, Iran.
Orbitopsella sp. Henson, *123*, p. 18, pl. 10, figs. 2, 3, 6, 10. Upper Triassic or lower Jurassic, Oman.
Palmerinella spp. Stainforth, *219*, p. 133, pl. 25, fig. 4. Miocene, Ecuador.
Patellina sp. Brotzen, *26*, p. 71, pl. 9, fig. 6. Paleocene, Sweden.
Planularia sp. A Cushman, *49*, p. 219, pl. 15, figs. 2, 3. Miocene, Maryland.
——— *sp. B* Cushman, *49*, p. 216, pl. 15, fig. 1. Miocene, Maryland.
——— *sp.* Dorsey, *86*, p. 284, pl. 30, fig. 7. Miocene, Maryland.
Polymorphina sp. Shifflett, *215*, p. 59, pl. 3, fig. 5. Eocene, Maryland.
Profusulinella sp. A Thompson, *227*, p. 87, pl. 29, figs. 1–4. Pennsylvanian, Texas.
Pyrgo sp. Renz, *202*, p. 155, pl. 3, fig. 3. Oligocene, Venezuela.
Pyrulina sp. Shifflett, *215*, p. 56, pl. 2, fig. 23. Eocene, Maryland, Virginia.
Quinqueloculina sp. Rau, *198*, p. 776, pl. 119, figs. 1–3. Miocene, Washington.
Reophax sp. Shifflett, *215*, p. 44, pl. 1, fig. 3. Eocene, Virginia.
Robertina sp. Parker, *188*, pl. 3, fig. 7. Recent, Atlantic.
Robulus sp. Cushman and Todd, *65*, p. 29, pl. 5, fig. 15. Eocene, Mississippi.
——— *sp. 1* Parker, *188*, pl. 2, fig. 12. Recent, Atlantic.
——— *sp. 2* Parker, *188*, pl. 2, fig. 13. Recent, Atlantic.
——— *sp. 3* Parker, *188*, pl. 2, fig. 11. Recent, Atlantic.
Saracenaria sp. Dorsey, *86*, p. 286, pl. 30, fig. 5. Miocene, Maryland.
Sigmoidella sp. Dorsey, *86*, p. 299, pl. 34, figs. 3, 4. Miocene, Maryland.
Spirocyclina sp. Henson, *123*, p. 20, pl. 10, figs. 8, 9; pl. 13, figs. 1, 2, 5, 6. Upper Jurassic, Arabia.
Spiroplectammina sp. Parker, *188*, pl. 4, fig. 21. Recent, Atlantic.
Stomatorbina sp. Dorreen, *85*, p. 296, pl. 39, fig. 5. Eocene, New Zealand.
Textularia ? sp. or *Vulvulina ? sp.* Renz, *202*, p. 171, pl. 1, fig. 24. Oligocene, Venezuela.
Triloculina sp. Parker, *188*, pl. 1, fig. 4. Recent, Atlantic.
Trochammina sp. Shifflett, *215*, p. 48, pl. 1, fig. 13. Eocene, Virginia.
Trochamminoides sp. Cushman and Renz, *61*, p. 10, pl. 2, fig. 4. Eocene, Trinidad.
Uvigerina sp. Parker, *188*, pl. 5, fig. 19. Recent, Atlantic.
——— *sp. A* Todd, *59*, p. 271, pl. 34, fig. 8. Recent, Pacific.
——— *sp. B* Todd, *59*, p. 271, pl. 34, fig. 9. Recent, Pacific.
Vaginulina sp. Cushman, *49*, p. 217, pl. 15, fig. 4. Miocene, Maryland.
——— *sp.* Dorsey, *86*, p. 286, pl. 30, fig. 6. Miocene, Maryland.
——— *sp. a* Renz, *202*, p. 176, pl. 4, fig. 23. Oligocene, Venezuela.
Valvulineria sp. Parker, *188*, pl. 4, fig. 13. Recent, Atlantic.
Virgulina sp. Parker, *188*, pl. 5, fig. 14. Recent, Atlantic.

NOMINA NUDA

The following *nomina nuda* were noted in the literature of the preceding Bibliography:

Cushman, in Lit. No. 49, refers to the following species from the Eocene of Maryland:

Bolivina virginiana Cushman and Cederstrom,
Ceratobulimina rotundata Cushman and Cederstrom
Cibicides speciosus Cushman and Cederstrom
Dentalina bevani Cushman and Cederstrom
Loxostomum longiforme Cushman and Cederstrom
Plectofrondicularia virginiana Cushman and Cederstrom

and

Robulus virginianus Cushman and Cederstrom

As the original paper by Cushman and Ceder-

strom has not yet been published, at least not during the year 1948, all seven species have to be regarded as *nomina nuda* from a nomenclatural point of view.

Ikebe, in Lit. No. 135, mentions *Lepidocyclina makiyamai* n. sp., and *Lepidocyclina ikebei* n. sp. *Lepidocyclina makiyamai* has been published correctly as a new species in Jour. Paleontology, vol. 23, 1949, p. 212, but *Lep. ikebei* is still regarded as a *nomen nodum*.

Sigal, in Lit. No. 217, mentions a new genus, *Cribrogloborotalia* gen. nov. which has not yet been published in accordance with the stipulations of the International Rules of Zoological Nomenclature. The same is the case with *Globotruncana brotzeni* n. sp. in Sigal, Lit. No. 216, p. 14.

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After submission of the Preceding bibliography to the Editor of this JOURNAL (May 1949) the following additional titles of publications on Foraminifera have come to the attention of the compiler, bringing the total of papers for the year 1948 to 321.

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 6, PP. 669–672, 10 TEXT FIGS., NOVEMBER 1949

NEW GENERA OF FORAMINIFERA FROM THE LOWER CRETACEOUS OF GERMANY AND ENGLAND

H. BARTENSTEIN AND E. BRAND
Celle, Germany

ABSTRACT—Three new genera of Foraminifera—*Hechtina*, *Falsoguttulina*, and *Tetraplasia georgsdorfensis*—occurring in the Lower Cretaceous of Germany, and one new genus—*Pseudonubeculina*—recorded from the Lower Cretaceous of Germany and England are described.

INTRODUCTION

RESEARCH on the taxonomy and biostratigraphy of Lower Cretaceous Foraminifera of northwestern Germany—especially of the Valendis-Foraminifera on which a monograph is in preparation—makes certain taxonomic revision necessary, and some new genera and species must be erected. Three of the new genera include calcareous and one includes arenaceous Foraminifera. Although these genera are now known only in Germany and England they will be found in the other parts of northwestern Europe.

We are very much obliged to Dr. Brooks F. Ellis, who examined the taxonomic validity of the new generic names by aid of the Catalogue of Foraminifera, which is not available to us in Germany.

SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERA
Family MILIOLIDAE d'Orbigny 1839
Subfamily HAUERININAE Brady 1884
Genus HECHTINA Bartenstein and Brand, n. gen.

Synonym.—*Hauerina* Reuss 1863—non d'Orbigny 1839.

Derivation of name.—In honor of Dr. Franz E. Hecht who first studied the Foraminifera as index-fossils of the Lower Cretaceous of northwestern Germany.

Genotype.—*Hechtina praeantiqua* Bartenstein and Brand, n.sp.

Generic diagnosis.—Miliolids with unequally inflated chambers which are arranged irregularly in a broken spiral and with a simple, not specialized aperture tangent to the older coil.

Remarks.—*Hechtina* has, by the uniqueness of the shape of the test and the simplicity of the aperture, no connection with other genera. Tests with more regularly arranged chambers resemble *Hauerina* and *Trisegmentina*, but these genera have cribrate apertures. *Parrina* and *Adherentina*, on other hand, are characterized by two irregularly arranged chambers, possess only a few chambers and a deviating aperture. Moreover, *Adherentina* is an attached form. *Hechtina* with its singular shape seems to be a passage-form between the subfamilies Nubeculariinae and Miliolinae.

Geologic distribution.—*Hechtina* occurs only in the older Lower Cretaceous (Middle Valendis to Middle-Barremian); rare to common, very characteristic.

HECHTINA PRAEANTIQUA
Bartenstein and Brand, n.sp.
Figures 1 a–c, 2 a–c

Description.—Test free, imperforate, porcellaneous in appearance, with broken spiral, shape varying from flattened to inflated; Nucleoconch with two, later with three, chambers forming a coil, latest whorl with three chambers, mostly irregularly arranged (fig. 1a–c), sometimes nearly regular (fig. 2 a–c). The chambers are unequally inflated, of different size and only towards the aperture more or less separated. Aperture simple, either low and slit-like or higher and rounded; immediately adjacent to the preceding whorl.

Type locality.—Deep well, Dueste 1, 510.5–516.3 m, Hannover (Germany).

Holotype.—Fig. 1 a-c, Collection Bartenstein and Brand, Celle.

Dimensions.—Diameter 0.4 mm.

Remarks.—*Hechtina praeantiqua* occurs commonly in the older Lower Cretaceous with numerous imperforate, attached or not attached tests which constitute an evolving

transformation series connecting the miliolid genera *Nodobacularia*, *Nubeculinella*, *Adherentina*, *Parrina*, *Reporta* and *Quinqueloculina* beginning in the Jurassic. This evolution ended in the Lower Cretaceous. Only *Hechtina praeantiqua* and *Hechtina antiqua* are specialized in such a way that their independence is demonstrated. *Hechtina antiqua* (Reuss) differs by its more regular test, mostly larger size, and coarse thick walls.

HECHTINA ANTIQUA (Reuss)
Figures 10 a–b (after Reuss 1863)

Hauerina antiqua REUSS 1863, Sitzber. k. Ak. Wiss. Wien, vol. 46, p. 35, pl. 2, fig. 1.

Description.—(after Reuss) "0.7 mm. gross, im Umrisse rundlich, 4–5 lappig, zusammengedrueckt, beinahe scheibenfoermig, mit schmalem abgerundeten Ruecken." . . . "Die letzte Kammer zieht sich allmaehlich zusammen und ihr stumpfes Ende wird ganz von der rundlichen oder halbrunden, ziemlich grossen, von einem schmalen Rande eingefassten Muendung eingenommen. Die Schale kalkig, compact, porenlos."

Dimensions.—Diameter 0.7 mm. and more.

Remarks.—This well known species is recorded especially from the Upper Hauterivian. The stratum typicum, described by Reuss as doubtful Barremian, is also Upper Hauterivian. Reuss' second recorded occurrence—Dogger with *Ammonites coronatus*—must be mistaken. The Upper Hauterivian occurs in this neighborhood and may have furnished his specimens. We have never found *Hechtina antiqua* in the Dogger.

This species differs from the older *Hechtina praeantiqua* by its more regular test, larger aperture, and very thick porcellaneous walls. Irregularity in ontogeny is rarer. *Hechtina antiqua* appears first in the lowest part of the Upper Hauterivian and vanishes in the Middle Barremian.

Subfamily NUBECULARIINAE Brady 1844
Genus PSEUDONUBECULINA Bartenstein and Brand, n. gen.

Genonym.—*Nubecularia* Chapman 1891; non Defrance 1825.

Derivation of name.—To indicate the morphological similarity with *Nubeculina*.

Genotype (monotypic).—*Pseudonubeculina nodulosa* (Chapman).

Generic diagnosis.—Few rectilinearly arranged chambers with an elongate, tubular neck and a terminal aperture; walls with irregularly attached sand grains.

Remarks.—*Pseudonubeculina* has the same shape as *Nubeculina* with all its peculiar walls and differs only in the internal structure of the aperture. The aperture of *Nubeculina* is "elongate, tubular, with an everted, phialine lip and inwardly pointing teeth" (Galloway 1933, p. 116)—*Pseudonubeculina* has a simple round aperture. The form of the initial chamber could not be studied for all tests were broken.

Geologic distribution.—Lower Cretaceous, rare; occurring in the Valendis and Hauterivian of northwestern Germany (Bartenstein and Brand), of Netherlands (ten Dam), in the Gault of Folkestone, South-England (Chapman) and Albian of Holland (ten Dam).

PSEUDONUBECULINA NODULOSA (Chapman)
Figures 3–5

Nubecularia nodulosa CHAPMAN, 1891, Jour. Roy. Soc. London, p. 9, pl. 9, fig. 2 (this work fig. 3).

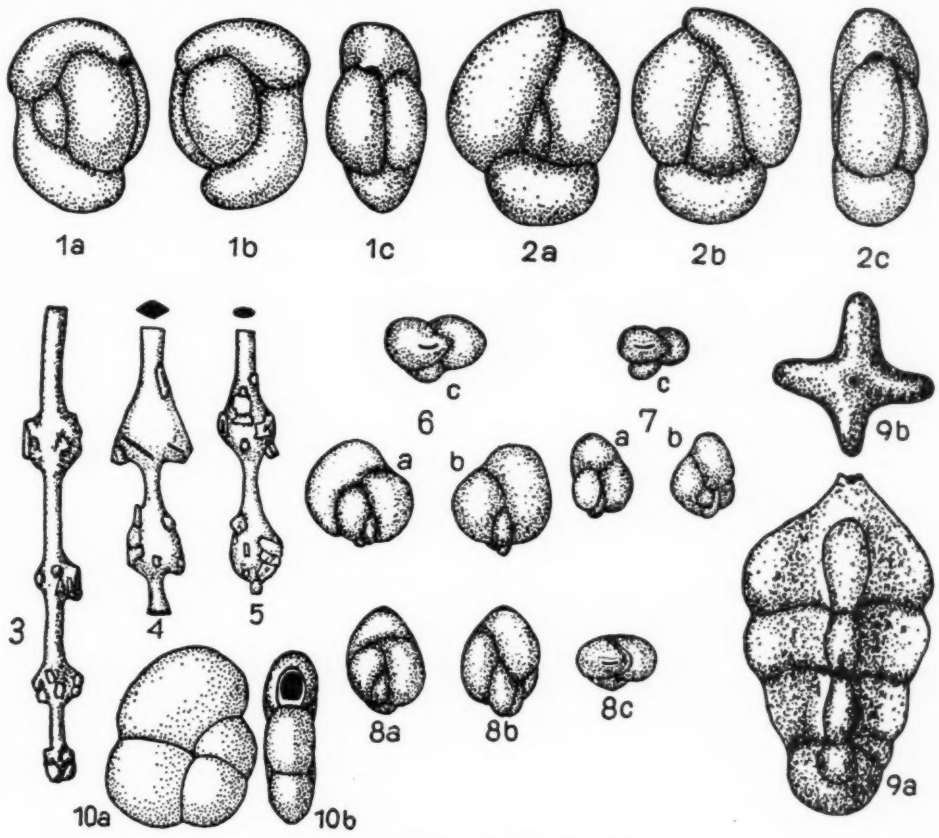
Description.—"A free-growing form, having nodulous chambers united by slender stoloniferous tubes, and rectilinear in growth. All the specimens found are apparently fragments; the longest consisted of four chambers. This form resembles in some points *N. divaricata* Brady; . . . etc. The aperture is a simple orifice, and not phialine, as in the form described by Dr. Brady" (Chapman 1891, p. 9).

A complete test with nucleoconch has not been observed, therefore, it is not yet certain if the juvenial chambers are rectilinear or coiled. The imperforate walls are irregularly covered with sand-grains. Removing the sand-grains shows the wall to be marked by small grooves. In section the apperture is generally round but according to the condition of the small neck which is likely to be deformed, it may be oval (fig. 5) or angular (fig. 4).

Typoid.—Figures 4, 5. Coll. Bartenstein and Brand, Celle.

Dimensions.—Length 0.6 mm. (fig. 4).

Remarks.—This species has been found only in the oldest and youngest parts of the Lower Cretaceous, in the Valendis, Haute-



EXPLANATION OF FIGURES 1–10

FIGS. *1 a–c—Hechtina praeantiqua* Bartenstein and Brand, n. gen. n. sp. Holotype ×65. *a* and *b*, side views; *c*, front view. (p. 669)

2 a–c—Hechtina praeantiqua Bartenstein and Brand, n. gen. n. sp. Paratype ×80. *a* and *b*, side views; *c*, front view. (p. 669)

3–5—Pseudonubeculina nodulosa (Chapman). *3*, after type figure, ×60, from the Gault of Folkestone; *4*, *5* from the Valendis of Germany, ×65 and ×75, with apertural views. (p. 670)

6 a–c—Falsoguttulina wolburgi Bartenstein and Brand, n. gen. n. sp. Holotype ×40. *a* and *b*, side views; *c*, apertural view. (p. 672)

7–8—Falsoguttulina wolburgi Bartenstein and Brand, n. gen. n. sp. Paratypes ×45. *a* and *b*, side views; *c*, apertural view. (p. 672)

9 a–b—Tetraplasia georgsdorfensis Bartenstein and Brand, n. gen. n. sp. Holotype about ×35. *a*, side view; *b*, apertural view. (p. 672)

10 *a–b—Hechtina antiqua* (Reuss), after Reuss 1863, ×35. *a*, side view; *b*, apertural view. (p. 670)

rivian and Gault. We suppose they occur throughout the Lower Cretaceous, but the fragile tests are mostly destroyed in disintegrating the rock.

In spite of its similar shape the difference of aperture distinguishes this species from *Nubeculina divaricata* of the recent seas.

Family POLYMORPHINIDAE d'Orbigny 1846

Genus FALSOGUTTULINA Bartenstein and Brand, n. gen.

Derivation of name.—To indicate the shape-analogy with *Guttulina*.

Genotype (*monotypic*). — *Falsoguttulina wolburgi* Bartenstein and Brand, n. sp.

Generic diagnosis.—Shaped like *Guttulina*, but the aperture instead of being radiate is a simple curved slit.

Remarks.—*Falsoguttulina* with its simple aperture occupies an isolated position in the Polymorphinidae unrelated to other genera. The occurrence of many adult tests, both large and small, prevents their confusion with degenerated polymorphid forms, which are found sometimes with non-radiate apertures (Cushman 1940, p. 203: "Aperture terminal, radiate, or in degenerate forms rounded").

Geologic distribution.—Valendis of Germany, locally common.

FALSOGUTTULINA WOLBURGI Bartenstein and Brand, n. sp.
Figures 6–8

Derivation of name.—In honor of Dr. Joh. Wolburg who first studied the index ostracodes of the German Wealden formation.

Description.—Test free, somewhat inflated, chambers arranged as in *Guttulina*, sutures depressed; 3 to 5 chambers forming a whorl. Wall calcareous, finely perforate, smooth. Aperture terminal, produced, slit-like, mostly curved. (This description refers to adult, non-degenerate tests.)

Type locality.—Deep well, Georgsdorf 6, 517.5 m. deep. Emsland, Germany.

Holotype.—Fig. 6 a–c, Coll. Bartenstein and Brand, Celle.

Dimensions.—Length 0.35 mm.

Remarks.—The arrangement of chambers and of sutures is extremely variable and scarcely any two individuals are exactly the same. It is impossible to discriminate species only on pecularities of shape.

Family LITUOLIDAE Reuss 1861
Genus TETRAPLASIA Bartenstein and Brand, n. gen.

Genonym.—*Triplasia* (part) Reuss 1854.

Derivation of name.—Indicating the quadrangular rather than triangular shape as in *Triplasia*.

Genotype (monotypic).—*Tetraplasia georgsdorfensis* Bartenstein and Brand, n. sp.

Generic diagnosis.—Lituolids with a quadrangular transverse section of the uncoiled portion.

Remarks.—*Tetraplasia* is closely related to *Triplasia* and occurs commonly with it.

Geologic distribution.—Known only in the Valendis and Hauterive, rare; its occurrence is likely to be the same as that of *Triplasia:* Jurassic to Recent.

TETRAPLASIA GEORGSDORFENSIS Bartenstein and Brand, n. sp.
Figure 9 a–b

Haplophragmium murchisoni REUSS 1891 *pars*, Beissel, Abh. koen. preuss. geol. Landesanst., N.F., H. 3, p. 15, pl. 4, fig. 2, 5, 9.

Description.—Test free, elongate, regularly increasing in size. Earliest chambers rarely recognizable but planispirally coiled (often the coiled part is only suggested by the irregularity of the juvenile chambers), later chambers uncoiled, quadrangular, walls depressed with more or less rounded edges; sutures somewhat depressed. Walls rather coarsely arenaceous. Aperture terminal, central, round or somewhat elongate.

Type locality.—Deep well. Georgsdorf 9, 625 m. deep. Emsland, Germany.

Holotype.—Fig. 9 a–b, Coll. Bartenstein and Brand, Celle.

Dimensions.—Length 1.25 mm.

Remarks.—The shape of *Tetraplasia georgsdorfensis* is very typical. Close relationship to *Triplasia* is indicated by individuals showing transitional characters.

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THE DETERMINATION OF THE CRETACEOUS-EOCENE BOUNDARY BY MEANS OF QUANTITATIVE, GENERIC, MICROFAUNAL DETERMINATIONS AND THE CONCEPTION "DANIAN" IN THE NEAR EAST

S. W. TROMP
Department of Geology
Fouad I University
Abassia (Cairo) Egypt

ABSTRACT—The diversity in opinion concerning the classification of the uppermost Cretaceous and basal Eocene is discussed. Evidence is presented to show that the Cretaceous-Eocene boundary can be established in the Middle East very accurately by using the method of quantitative generic analyses. The boundary cuts through the so-called Danian and makes this term superfluous, at least in the Middle East. Further evidence suggests that in other countries also the term Danian is useless as an accurate stratigraphic unit and should be abandoned.

PREVIOUS CLASSIFICATIONS OF UPPER CRETACEOUS STAGES

THE stratigraphic classification of the Senonian and the determination of the boundary between the Cretaceous and the Eocene represents one of the many unsolved problems in stratigraphy which is a continuous cause of disagreement among geologists.

Ed. Hebert (1856) considered Montian and Danian as one unit and referred both to the Cretaceous.

H. Coquand (1858) distinguished Dordonian (similar to the Maestrichtian, introduced by Dumont in 1849), Campanian, Santonian and Coniacian.

A. de Grossouvre (1889, 1901) included both Montian and Danian as a single unit in the Tertiary.

A. Geikie (1903) distinguished Danian (divided into Montian and Maestrichtian) and Upper Chalk.

A. de Lapparent (1906) divided the Senonian into 6 units: Montian, Danian, Aturian (subdivided into Maestrichtian and Campanian) and Emscherian (divided into Santonian and Coniacian).

Em. Haug (1908) distinguished 5 units: Danian, Maestrichtian, Campanian, Santonian and Coniacian.

A. W. Grabau (1921) distinguished Danian, Senonian (divided into Maestrichtian, Campanian, Santonian) and Coniacian or Emscherian.

These few examples clearly show the complete disagreement that has existed among prominent geologists in several parts of the world.

ORIGINAL DEFINITION OF DANIAN

The original stratigraphic unit indicated by Desor (1846) as Danian occurs in North Jutland and on the Danish Islands below a cover of glacial depositions. The same beds were also reported from Skåne in Southern Sweden. In both countries the so-called "Danian" overlies the so-called "Maestrichtian" conformably without hiatus. The Danian was described as "Organic limestones often rich in Silex." It is overlain by conglomerates composed of Danian limestone pebbles resembling those of the Montian in Belgium. The Montian is apparently missing in Skåne.

MICRO-FAUNAL BOUNDARY BETWEEN CRETACEOUS AND LOWER EOCENE IN THE MIDDLE EAST

Observations by the present author (Tromp, 1941) in Egypt, Sinai and Turkey and descriptions published by F. R. S. Henson (1938) on Iraq and Palestine indicate that the Senonian and the transition zone of the Eocene are composed of the same kind of marls with no erosional hiatus at the Cretaceous-Eocene boundary. It is impossible to trace this boundary in the field on a lithologic basis. In 1937 the author developed a new micro-faunal method, in which only quantitative generic determina-

tions are used (Tromp 1939, 1940). It has been demonstrated to be particularly useful in the study of poorly exposed sections such as the Cretaceous-Eocene sections of southern Turkey (Tromp 1942), particularly those developed in the Anatolian facies (for difference between Anatolian and Arabian facies of the Middle East see Tromp 1943). With this method it has been possible to locate the Cretaceous-Eocene boundary within a meter. In 1941 a micro-faunal chart was published (Tromp 1941) which represents a compilation of a few important Cretaceous-Eocene micro-faunal sections of the Middle East, developed either in a chalky facies rich in forams (Arabian facies) or in grey marl facies relatively poor in forams (Anatolian facies).

This map and the micro-faunal studies made during the following years indicate a number of micro-faunal differences between the uppermost Cretaceous and basal Eocene, which can be summarized as follows:

1) The uppermost Cretaceous contains thousands of specimens of *Gümbelina*, many larger than 0.6 mm., whereas the basal Eocene contains only a few (in general less than 50), all smaller than 0.2 mm.

2) *Globorotalia* suddenly floods the basal Eocene. Specimens are mostly sharply keeled forms belonging to *Globorotalia simulatilis* (Schwager) and *Globorotalia velascoensis* (Cushman).

3) In the basal Eocene *Globigerina* is much more abundant than *Globigerinella*, whereas in the uppermost Cretaceous they are about equal and in the Campanian (of the Arabian facies) *Globigerinella* mostly dominates.

4) *Globotruncana* is abundant in, or floods, the uppermost Cretaceous but is absent in the Eocene.

5) Typical genera, such as *Pseudotextularia* and *Bolivinoides*, occur in the Cretaceous with such characteristic species as *Bolivina incrassata* (Reuss), *Gaudryina rugosa* (d'Orb), *Anomalina ammonoides* (Reuss), etc. Exceptionally, *Eouvigerina*, *Gümbelitria*, *Ventilabrella* and *Neobulimina* also occur in the uppermost Cretaceous of Egypt.

The Upper part of the Cretaceous is known in the Middle East as the *Globotruncana-Gümbelina* zone, whereas the basal Eocene is recognized as *Globigerina-Globorotalia* zone.

Nummulites and *Discocyclina* have been found, at a few places not far above the Cretaceous-Eocene boundary and above beds with typical Upper Cretaceous macro-fossils. The occurrence of macro-fossils, however, is exceptional and micro-faunal analysis must be used for field-mapping, particularly in chalk areas where Cretaceous and both Lower and Upper Eocene chalk outcrops, which can not be distinguished on a lithological basis, may occur very near to one another.

MICRO-FAUNAL CLASSIFICATION OF THE SENONIAN

By using the methods mentioned above (Tromp 1939, 1940) the Senonian in Egypt and Turkey has been divided into three stratigraphic units which have been tentatively termed Maestrichtian, Campanian and Santonian (Tromp 1941, 1942, 1943).

A division into 5 to 6 units as proposed by Haug and others is impossible.

It is also unlikely that a larger number of practical units, useful for regional correlation, can be recognized because the entire Senonian is only about 200 to 300 meters thick.

The three micro-faunal units may contain macro-fossils strictly limited to the Maestrichtian, Campanian or Santonian respectively, but it is not unusual for a Campanian species of Europe to occur with a Maestrichtian fauna or vice versa. Such associations might create confusion and can be explained as follows:

1) The stratigraphic distribution of macro-fossils in general is much less known than is the distribution of Foraminifera, which have been studied in various parts of the world in continuous well sections and surface outcrops thousands of meters thick.

2) Many different Senonian classifications have been proposed in Europe and some research workers have used more than one system at the same time. The age of strata containing a particular fossil species even at localities hundreds of kilometers apart, has commonly been considered, without critical analysis, to be the same. This method of correlation used by so many macro-paleontologists, not checked by strat-

igraphical field observations, is one of the most serious handicaps of modern stratigraphy.

3) A system of index fossils established for a small type locality in Europe, as for the Campanian, Santonian, etc., has been pressed into use in other areas where the stratigraphic section is actually more representative but was unknown at the time that the names of the geological stages were introduced.

CRETACEOUS-EOCENE "UNCONFORMITY"

No indication of an erosional hiatus at the Cretaceous-Eocene boundary occurs in the Middle East, but an important regional hiatus is present near the base of the Middle Eocene (probably similar to the Lutetian of the French classification) which may have resulted from the same movements that created the Red Sea graben. Middle Eocene beds overlap the upper lower Eocene onto the basal Eocene and may directly overlie Maestrichtian or older Cretaceous strata. Such relations have commonly been interpreted erroneously as evidence for a Cretaceous-Eocene unconformity.

Another reason for the incorrect interpretation of the Cretaceous-Eocene boundary is the limestone development of the lower Eocene in Egypt. In southern Egypt thick cherty lower Eocene limestone is underlain by a thin (sometimes less than 10 meters) marl unit, the so-called "Esna shales," which cannot be distinguished lithologically from the uppermost Senonian. It is not surprising therefore that, before the introduction of micro-faunal methods, the lithologic contact between limestone and marl was accepted as the Cretaceous-Eocene boundary. Northward, however, the basal Eocene marl thickens gradually. In Sinai it is more than 50 meters thick and in southern Turkey it reaches a thickness of almost 450 meters.

THE DANIAN IN THE MIDDLE EAST

The difficulty in accurately distinguishing the Cretaceous-Eocene boundary in the Middle East is one of the reasons for the introduction of the name Danian for this transition zone.

Micro-paleontological evidence, however, indicates that its recognition is unjustified and it is advisable that this term be eliminated at least in the Middle East.

It seems possible also, in Germany (Franke 1928), Italy (Renz 1936) and Morocco (Fallot 1937), where previously certain zones were described as Danian, to trace a very accurate micro-faunal boundary somewhere in the middle of this unit, which makes the use of the term Danian superfluous.

The lithology of the Danian of Denmark seems to resemble the basal Eocene of Sinai and Egypt. In northeastern Sinai, East of Gebel Halal, along the road to Qusaima near Palestine border, the lower Eocene is composed of marly limestones and chalk rich in chert which is unconformably overlain by pebbly limestones and chalk possibly of middle Eocene age although the break might be a local unconformity in the lower Eocene. Perhaps also, the so-called Montian in Denmark, unconformably overlying the so-called Danian, may not be the true basal member of the Eocene as was assumed by Desor in 1846.

In 1936 Brotzen reported on the microfaunal at Eriksdal in Skåne, southern Sweden. Quantitative determinations were made of two chalky marl samples (i.e. the total number of forams in the whole sample was counted). Transformation of his table into my graphic method of representation shows that the fauna studied by Brotzen is similar to that of the Campanian or basal Maestrichtian of Southern Turkey (Arabian facies). Brotzen considered this zone to be Emscherian (basal Senonian). The distance between Turkey and Skåne is so great, however, and there is so little accurate data from intermediate areas that it seems unsafe to draw definite conclusions from the similarity.

If a systematic micro-faunal study could be made from the Middle East through the Balkans and Central Europe to Scandinavia it would probably become apparent that the Senonian classification of the 19th and early 20th centuries should be revised and only three simplified units recognized. The Danian would probably prove to be a superfluous unit that has been useful only because of the great difficulty experienced in determining the Cretaceous-Eocene boundary by means of macro-fossils. The original Seno-

nian classification is derived from only a very small area in western Europe and it does not seem advisable to try to force the stratigraphy of the whole world into this system. Perhaps the concept that important orogenetic movements occurred at the end of the Cretaceous period is not correct or not applicable to the whole earth. Possibly a more significant break occurs near the base of the middle Eocene.

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PALEONTOLOGIST—BIOLOGIST AND/OR GEOLOGIST?

L. RAMA RAO
Bangalore, India

FOLLOWING Dr. Knight's recent Presidential Address before the Paleontological Society[1] an interesting discussion has ensued regarding the place of Paleontology among the Natural Sciences; and as a geologist who is interested in the study of fossils, I wish to make a few observations and comments on the views that have been expressed in this matter.

In his enthusiasm to make out a strong case that paleontology is—or should be—only a part of geology, Professor Weller[2] has made several statements which are highly controversial regarding the scope of paleontology and the related sciences, and has adopted a line of argument in support of his conclusion which it is difficult to follow, and more so, to accept. Newell and Colbert[3] have already challenged some of these statements and put forward a different point of view. After reading all that Weller has said in the course of this discussion, I am of the opinion that in advocating his case, he has been hardly fair to the scope, objectives, and mutual relationships of paleontology and the allied sciences, as understood today.

It is true, thanks to William Smith, that the geologist was the first to see the value of fossils. They helped him in the correlation of strata, and he therefore immediately became interested in their identification and a particular fossil was to him an index of age and a valuable aid to correlation. Among the fossils which the geologist found, the invertebrates were by far the most common and abundant and they were also the easier to identify and thus be used for stratigraphic correlation. These invertebrate fossils served —and served very well—his immediate purpose and he was quite satisfied. Beyond this, he had no interest in them. Thus the view gradually developed that such a study of invertebrate fossils or "invertebrate paleontology" was the only thing that was of importance, and that this subject formed part of stratigraphical geology. It was only much later that the vertebrate fossils and plant fossils came into the picture; but compared with the invertebrates, these were neither so abundant nor were they so easy to describe and identify. Hence they were not so useful to the geologist in his work of correlating strata and, therefore, did not receive much attention from him. There soon grew up, however, a body of scientists who looked at these fossils as the representatives of past forms of life and they interested themselves in their study *as such*. Thus some zoologists and botanists began to direct their attention to the study of these ancient animals and plants and such persons came to be looked upon as paleo-zoologists and paleo-botanists. The importance of their work was soon evident, especially in the correct understanding of the evolution of modern animals and plants, and hence more and more zoologists and botanists who were interested in the study of evolution tended to become paleo-biologists. *They* were the people that revealed to us the importance of fossil vertebrates and fossil plants which were being more or less discarded as useless by the geologist for *his* purposes. It did not take very long, however, for us to also recognize that, apart from their value to the biologist in his evolutionary studies, these fossils were also useful in their own way to the geologist in connection with stratigraphic and other problems relating to the past history of the earth.

This is how interest in fossils gradually developed in the earlier years from different sides, although with a limited outlook in each case. Now, after many years of work and progress in the different aspects of the study of fossils, we have come to a stage when we can take—and indeed it is necessary to do so—a collective and comprehensive view of the entire picture in so far as the study of fossils is concerned and assign to it an appropriate place in the hierarchy of the sciences. This is the problem now under discussion.

[1] Bull. Geol. Soc. America, vol. 58, pp. 281–286, 1947.
[2] Jour. Paleontology, vol. 21, no. 6, pp. 570–575, 1947; *ibid.*, vol. 22, no. 2, pp. 268–269, 1948.
[3] Jour. Paleontology, vol. 22, no. 2, pp. 264–267, 1948.

If we review and integrate all the work that has been done within recent years on the study of fossils in all its aspects and ponder over its diverse and far-reaching applications and implications, the one fact that will strike us is the overall importance of these studies for a proper and full understanding of earth history as a whole which comprises its physical, geological, geographical, and biological aspects and their interrelationships. In attaining this greater ground" of both geology and botany. Some may enter that field from the side of geology as geologists, and others may enter from the side of botany as botanists but, once they get into it, all merge into a common group interested in the study of fossil plants deriving their knowledge and inspiration from both the sciences concerned and by their cooperative effort arrive at ideas and conclusions which, in their turn, may throw further light and open out new lines of re-

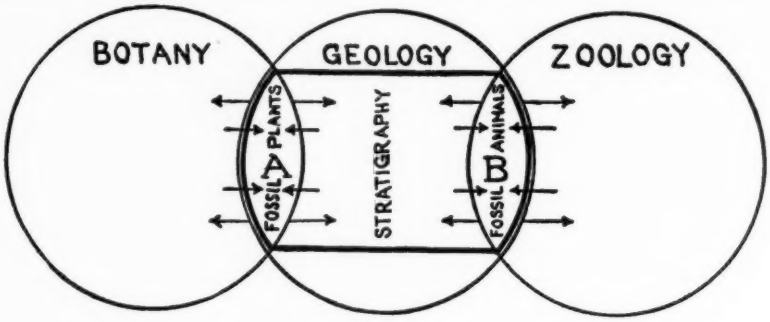

FIG. 1

and grander objective, the study of fossils —paleontology—rises above all other subjects of which it may have formed a part in a smaller sphere and occupies an elevated position from which it can illuminate our path and guide us properly in our quest for knowledge regarding the history of the earth, in its fullest sense. It is no longer correct to say that simply because paleontology has some contact with geology through stratigraphy that it should be considered merely as a part of it; it would be equally incorrect to think that, because of its contacts with biology, paleontology is only a part of biology. Nor is paleontology according to our present concept merely paleobiology plus stratigraphy. These may be its ingredients but in the way it blends and deals with them, bringing out new ideas and new viewpoints, the subject has an individuality of its own.

I have put these ideas in a diagrammatic form in the accompanying figures which will help in explaining my point of view. In figure 1 I have shown the contacts of Geology with the other natural sciences, botany and zoology. Portion A represents the field covered by the study of fossil plants, and is seen to be the "common search in botany on the one hand and in geology on the other. A similar situation exists in portion B which deals with fossil animals and is common ground between geology and zoology. In either case, A or B, the direct contact, so far as geology is concerned is with its central part—its "heart" as Weller puts it—viz. stratigraphy.

In figure 2 I have diagrammatically represented what I consider the position of paleontology in relation to the three sciences, geology, botany, and zoology, and I have indicated by means of arrows the various approaches to paleontology from each of these sciences. It will be seen that a direct approach is no doubt possible from either geology, botany, and zoology but this is the course adopted by those who have their feet most firmly planted in their respective sciences and take some interest in the study of fossils from a narrow and limited point of view to meet their immediate requirements. The other approaches, though seemingly indirect, are the more valuable and fruitful from the larger point of view. In these cases the botanist and the zoologist enter the field of paleontology *via* stratigraphy and the stratigraphical geologist enters it *via* paleobotany or paleozool-

ogy, imbibing in each case, the spirit of the cognate science. When once these enter the field of paleontology, they all develop a community of interest and objectives, and by their co-operative effort advance the science of paleontology as a whole. These are the true paleontologists and, at that stage, paleontology (this term is certainly a "more inclusive category" than paleobiology) is something more than merely a part of, or who desire to secure it. In making paleontology an independent science it does not mean that in one stroke we are isolating it and cutting off all its affiliations and contacts with geology and biology. All that we wish to establish is that it is not merely a part of one or the other of these subjects. If the term "independent" is to be literally understood, no science can be really independent today!

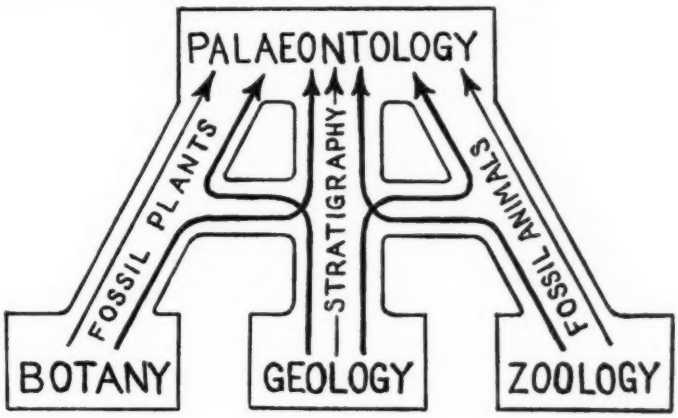

FIG. 2

branch of, either geology, botany, or zoology.

This I think is, or should be, the place of paleontology *vis-à-vis* the other natural sciences, and accordingly it follows that it is no longer fair or correct to consider paleontology merely as a branch of either geology or biology, or to think that either of these subjects can "manage to get along quite well in blissful and almost complete ignorance of paleontology." Weller says that "so separated, it (paleontology) would be given the superficial appearance of greater importance without adding one whit to the scope of its field or making possible any additional accomplishment" and thinks that "the desire to set up paleontology as a separate science suggests a professional inferiority complex." I am afraid this point of view is positively unfair and does less than justice to the objectives and achievements of modern paleontological studies. To me it appears that the inferiority complex exists on the side of those who deny a separate status for paleontology and not in those

In the course of this discussion frequent reference has been made by Weller and others to the training of paleontologists. Attention has been drawn to the deficiencies in our courses as they exist at present and suggestions have been put forward from various points of view as to how these could be bettered. This, I think, is a different matter, and should have nothing to do with our defining the scope and status of the science. When once this is done, and we know exactly what our requirements are, a suitable course of training for the prospective paleontologist could easily be framed with due regard to his contacts with other sciences. In any scheme, it seems certain that the paleontologist will be the product of post-graduate specialization, a good knowledge of the allied sciences having been acquired in the graduate courses. As in all other sciences, the ultimate success and achievement of a paleontologist will largely depend upon his own initiative, interest, and imagination in this field of research.

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PALEONTOLOGIC CLASSIFICATION

J. MARVIN WELLER
University of Chicago

ABSTRACT—The introduction of an ever increasing number of new generic names renders paleontological nomenclature unstable and changing phylogenetic interpretations result in an unstable classification that becomes progressively less practical. From the standpoint of paleontology as a whole reasonable stability in nomenclature and reasonable practicality in classification are desirable. To achieve these ends it is suggested that many current genera be reduced to subgeneric rank and that genera and families be accepted as more or less inclusive morphologic groups which need not conform perfectly with phylogeny. No previously recognized "genus" need be abandoned. As subgenera, however, these groups would remain available to specialists for tracing possible phylogenetic patterns but they could be ignored by paleontologists who are not concerned with such details.

INTRODUCTION

IT IS very easy for paleontologists to propose new names or draw up new systems of classification without regard to the inevitable effects of such action. That definite philosophical and practical problems are involved is realized by most thoughtful persons but few appear to have analyzed them carefully. Each person is likely to become so engrossed in his own particular field of specialization that he loses perspective and is inclined to overestimate the importance of his work and underestimate or ignore the effects that it may have on paleontology as a whole. Such an attitude may not characterize paleontology more than some other branches of science although I suspect that it does because paleontology still appears to be concerned principally with augmenting and revising complex systems of nomenclature and classification that are of common concern to all. The fact that biologists, who were formerly occupied with similar activities, have largely passed on to more fruitful studies suggests that paleontology is still in its infancy and should be encouraged to grow up. Continued preoccupation with the naming of new species and genera and their reclassification without regard to other matters that should be considered advances paleontology as a whole very little and in some respects may actually be harmful.

In their taxonomic activities paleontologists operate under a series of rules and by a system of procedure that were developed and formulated by biologists. Both of these had their origins in a period antedating the general acceptance of any doctrine of evolution when species were believed by most to be fixed and immutable, each a special act of creation. The acceptance of Darwin's theory profoundly altered biologic thought but taxonomic practice has remained practically unchanged. For a time the concept of species was thrown into great confusion from which biologists have only recently extricated themselves. Species, which a few years ago could be defined only as groups of similar organisms considered to be species by a competent expert, have acquired new and significant meaning to biologists in the light of discoveries made in the fields of genetics, zoogeography and population studies. The number of reasonably well established living species now recognized in some of the better known groups of animals exceeds the doubtful ones in about the proportion of seven to one, and the doubtful forms are mainly those which may or may not have diverged from closely related groups sufficiently to be considered distinct species.

PALEONTOLOGIC VS. BIOLOGIC SPECIES

The situations faced by biologists and paleontologists, however, are vastly different. In the first place, paleontologists deal with the imperfectly preserved remains of dead organisms. It is impossible for them to know these organisms completely, to determine their genetic compositions or to observe their reactions to environments. Also, the factors of geologic time and the

continuity of life introduce an additional dimension with which biologists are not concerned. If a complete life record were available we believe that not only would the most clearly distinguished living species be joined by an uninterrupted series of intermediate forms but that all past life would fall into an unbroken system ramifying outward along a myriad of branching lines from the first speck of matter that possessed the mysterious quality of life. In such a system how can a species be defined?

Because paleontologists cannot test the validity of species as effectively as biologists, it is much more difficult for them to establish the entities of species even for an instant in geologic time. When the factor of continuous time is also introduced to further complicate this problem, the concept of modern biological species breaks down entirely. It must be recognized, therefore, that a living species as viewed by a biologist, and a species, living or extinct, no matter how it may be defined by a paleontologist, are not the same. These two concepts exist on different planes and are not subject to significant comparison.

Presumably there have been no important breaks in the chain of life since its first appearance on the earth. There is no place in the life succession to which one can point and say "this creature is a cystoid but its descendants are crinoids," or "this beast is an amphibian but its offspring are reptiles." Likewise, viewing the situation in greater detail, one cannot state that species *primus* existed through a certain definite number of generations and that species *secundus* had its inception in the next succeeding one. However a paleontologist may think of a species, it grades imperceptibly into an ancestral species in one direction and may pass into one or more descendant species in the other. Whatever characteristic individuality even that most clearly distinguished species may possess results from chance imperfections in our knowledge. As new discoveries are made some of these gaps are filled in and the limits of recognizable species become progressively less well defined.

From the paleontologist's point of view a species is only a concept whose limits are determined by chance and personal opinion. This fact is, of course, widely recognized. It is a concept tied to reality by a type specimen and at present there is nothing to prevent every person who views that specimen from building a different concept about it. Although all may have decided opinions on the subject, no one can justly maintain that any of the different concepts is certainly wrong as long as the conceived species includes the type specimen as one of its members.

We can now contrast more adequately the biological and paleontological viewpoints regarding species. To a biologist, a species is a population having certain peculiar, more or less constant genetic characters, that occupies a certain ecological niche within a certain geographic range and that is isolated either physically or physiologically from all closely related species. Presumably a paleontologic species should be defined in somewhat similar terms with the added provision that it existed throughout a certain time. So far as I know, however, it never has and most paleontologists have dealt with species without having any clear ideas as to what their species really are. Perhaps a paleontologic species cannot be defined in such a way because some of these factors cannot be or have not been determined. Genetics is, for the most part, beyond the reach of paleontology. Ecological studies of past populations are in their infancy and little or no evidence concerning some of the most important variable conditions is preserved in the stratigraphic record. Considerable attention has been given to geographic range but until the species themselves are better understood conclusions are not too trustworthy. Finally, the definite isolating factors that may have been important are largely unknown except for some of the most prominent physical barriers and many of those that have been postulated are highly speculative to say the least.

Paleontologists should recognize, however, that the species with which they deal were likewise once living populations possessing all of the qualities of modern populations. Mostly paleontologists do not seem to have done so. Because of evolutionary continuity paleontologic species cannot have the distinctness of most biologic species but this does not weaken such a viewpoint. The indistinctness of specific limits, however,

introduces an important subjective element and thus reduces a paleontologic species from the concrete entity of most biologic species to the level of a concept. This concept, as held by different persons centers around the type specimen in varying degrees and two principal points of view prevail. First, the species may be considered to be defined by the type specimen and only those other specimens sufficiently similar to the type are included. Second (and this is the more modern view), the species is defined by all the known specimens that are rightfully referable to it and the type specimen is of no greater importance than any other except that it is the name bearer.

GENERA AND HIGHER CATEGORIES

The genus is a concept to both biologists and paleontologists. It consists of the type species and other closely similar and, usually, presumably closely related species. The closeness of the required similarity or relationship, however, cannot be specified and the opinions of individuals vary between wide extremes. Many species of modern organisms arrange themselves rather naturally into genera because of the absence of intermediate forms and thus their genera take on a semblance of reality. This is not so true of paleontologic genera which lose their horizontal distinctness as they are traced backward in time, and also grade vertically into antecedent and subsequent genera. Consequently, paleontologic genera, which are second order concepts, are likewise complicated by the time factor and they are considerably more subjective than most biologic genera which are first order concepts and not concerned with time.

Although the species is the fundamental unit of taxonomy, genera are actually the basic groups which are combined in building systems of classification. It may be fairly evident that one genus was directly derived from another but it is rarely possible to determine with reasonable certainty that one species is really a direct descendant of any other. From genera up, each taxonomic category is a concept based on other concepts and each is further removed from the reality of the type species or the type specimen. Even though they are far removed from reality in this way, some of the higher categories actually are more distinct and unified groups, as contrasted with others at their respective levels, than are the lower categories. This results, evidently, from their earlier origin and the consequent greater rarity of intermediate forms. Thus a phylum, a class or an order may be a more logical group which accords better with morphological consistency than a family, a genus or even some species as each is judged by the characters considered to be important at its particular level. Thus the differences of opinion are greater and instability in classification is likely to be most common in the lower categories and chiefly concern the combination of species into genera and the uniting of genera to form families.

Taxonomic differentiations that have come to be recognized in many groups are so numerous that the seven fundamental categories (kingdom, phylum, class, order, family, genus, and species) are not sufficient to accommodate them all and many intermediate categories are required. No means has been devised, however, to standardize these categories or to define them with respect to grades of morphological difference or genetic relationship. Consequently it is not possible to state that a certain degree of differentiation characterizes a subgenus and another degree a genus and usually the rank assigned to any group is determined by some individual whose opinion is accepted more or less unreasoningly by others. Therefore, genera (or units in any other category), as recognized in one group of organisms, may not be comparable to the genera in another on the basis of the grade of morphological difference or genetic relationship.

PURPOSE OF CLASSIFICATION

There are two very good reasons for attempting to work out a sound classification of organisms. First, a classification is necessary in order to organize a mass of data so vast that, in its entirety, it is beyond the comprehension of any individual. Only by classification can its general patterns and scope be understood and remembered. Such a need was early recognized and pre-Darwinian classifications were based upon the qualities of morphological similarities and differences. Such classifications were primarily practical and useful in as much as

they not only organized knowledge but also served as an aid in identification by application of the process of elimination.

The second purpose that a classification may fulfill is the indication of patterns and degrees of phylogenetic relationship. Since the acceptance of the theory of evolution such an objective has been more and more widely recognized as the proper aim of classification and such a classification is commonly termed a "natural" one. At the present time this view is so universally held by both biologists and paleontologists that anyone who does not subscribe to it is generally considered to be unenlightened and reactionary.

Only a specialist who is intimately familiar with a particular group of organisms can construct a classification that is satisfactory in a practical way or convincing phylogenetically. Because of his knowledge such a specialist does not require a practical classification for his own use and consequently he is almost certain to build a classification which he considers to be "natural" forgetting or ignoring the requirements of many others for a practical short cut to the knowledge he has laboriously acquired.

Most paleontologists will agree that it is desirable for a classification to be both "natural" and practical. Unfortunately, experience has shown that this is impossible in conformity with present practices. With the accumulation of more abundant and more detailed information, new conclusions regarding phylogeny are reached and the classification is changed accordingly. In consequence, classification becomes steadily less practical and useful at the same time that the increasing number of described species and genera makes a practical and useful classification more necessary.

This movement of classification away from usefulness and practicality indicates that systematists consider phylogenetic classification to be an end in itself. There is no convincing reason for this conclusion, however, except for the contention that it is self evident. I recognize that search for the true phylogeny is a proper and very important field of investigation but I do not believe that it should be accepted as the one supreme goal of paleontologic research.

CLASSIFICATION BASED ON MORPHOLOGY

Any reasonable phylogenetic classification is actually a morphological one. Only morphology can be observed and on its basis conclusions regarding phylogeny are drawn. This is a fact that should be clearly recognized. A phylogenetic classification, therefore, is nothing more than a special type of morphologic classification. It differs from others only by the introduction of a subjective element requiring the interpretation of morphological similarities and differences in terms of probable phylogenetic significance.

The assurance with which systematists refer to a supposed phylogenetic classification as a "natural" one, thus implying classification on any other basis to be unnatural, seems to me unwarranted and quite misleading. I contend that any logical classification based on facts (that is, based on observed characters and not undetermined or imaginary ones) can be rightly designated natural. From this point of view, a phylogenetic classification may be less natural than one which is frankly morphologic because of the dependence of a phylogenetic classification on interpretation.

A perfect morphological classification (and this includes phylogenetic ones) should be based on all determinable characters. For both practical and theoretical reasons, however, some characters must be given more weight than others. Such weighting involves choice and inevitably leads to differences of opinion. The quest of phylogeny does nothing to improve this situation but is likely to aggravate it because specialists in the same field can rarely agree completely concerning the significance of details and they may reach widely varying conclusions with regard to obvious and probably fundamental differences. Each is likely to present his classification as the only "natural" one but, in invertebrate paleontology at least, the subjective element of interpretation looms so large that there may be little choice between them.

As an example, Wachsmuth and Springer believed the division of Paleozoic crinoids into camerates and inadunates to be fundamental but Bather contended that the distinction between monocyclic and dicyclic forms is more important. Or, compare the

foraminiferal classifications of Cushman and of Galloway. These are based upon quite different assumptions as to what characters are primitive and they also differ in many other important respects. Obviously, in either example, both proponents cannot be right and quite possibly both are wrong with respect to the true phyletic pattern.

THE PROBLEM OF CLASSIFICATION

Inescapable doubts regarding the validity of assumptions as to the relative significance of different characters and their interpretation from the standpoint of phylogeny should give every systematist pause. They should make him consider most carefully whether the sacrifice of practical usefulness, which may result from the adoption of a new "natural" classification, is justified. An impartial judgement, it seems to me, will in many cases indicate that it is not.

The importance of classification to paleontologists who are not primarily systematists is so great that their interest in this problem deserves most serious consideration. Certainly the instability that results from ever changing phylogenetic interpretations is most confusing to all but specialists in their own fields. Is it not possible to devise some system of classification that will at the same time preserve a reasonable amount of stability, practicality and simplicity greatly desired by general paleontologists and also possess the flexibility required by specialists?

Although the suggestions which I have to offer are the result of long consideration, I present them with considerable misgivings. This is not because they are certain to meet with many objections, but because I am not sure of the best approach to this problem. If, however, paleontologists in general can be brought to realize that such a problem exists and if systematists and specialists in various fields can be brought to concede that this problem is worthy of consideration, my present objective will have been achieved. Therefore, I offer these suggestions with the hope that they may provide the basis for further consideration and discussion reflecting various divergent viewpoints. If general paleontologists and systematists can approach this problem objectively and with a sympathetic understanding of the interests and needs of each other, there is a possibility that a solution acceptable to all may be reached.

Before presenting my suggestions, I must state my belief that there is no *a priori* reason why an acceptable classification should be strictly phylogenetic in all its details. In the first place, almost all paleontologists will admit that there is no reasonable prospect that any such perfect classification can ever be achieved. Possibly the main lines of phylogeny may be worked out to everyone's satisfaction eventually but imperfections in the record will render some details forever doubtful. In the second place, if such a classification were possible it could be so intricate and require the recognition of so many taxonomic grades that all but the most fanatical systematists would recoil from it. Therefore, it seems to me that we must inevitably face the question: How far is it reasonable to insist that the principle of phylogeny must be carried in classification?

DEGREES OF HORIZONTAL CLASSIFICATION

In a truly phylogenetic classification all species included in a genus (or any other group) must have descended directly from a single species. But should this ancestral species be a member of the younger genus (fig. 1, A or B) or may it be a terminal member of an older one (fig. 1, C)? This question does not seem to be particularly important in connection with genera but when the principle involved is applied to higher taxonomic categories it becomes significant. Genus C, however, in a strict sense is polyphyletic because it includes more than one entirely separate line of descent.

A consideration of all possibilities shows that genera based on the grouping of species according to morphological similarities fall into one or another of five classes as follows:

1—All species descended from a single ancestral species (No. 7) included within the genus (fig. 1, B).

2—All species descended from a single terminal species (No. 2) of the ancestral genus (fig. 1, C).

3—All species descended from a species (No. 4) not terminal in the ancestral genus (fig. 1, D)—parallel evolution.

4—Species descended from more than one entirely separate line included in the ances-

tral genus (fig. 1, E)—sustained parallel evolution.

5—Species descended from ancestors included in more than one antecedent genus (fig. 1, F)—convergent evolution.

A strictly proper phylogenetic (monophyletic) genus can belong only to the first class, and genera of each subsequent class become more characteristic of so-called horizontal classification which produces what are commonly termed form genera or genomorphs. If all groups are of the type characterized by Class 1 above, the largest group in question is descended from a single species included within it as strict phylogeny demands (fig. 2).

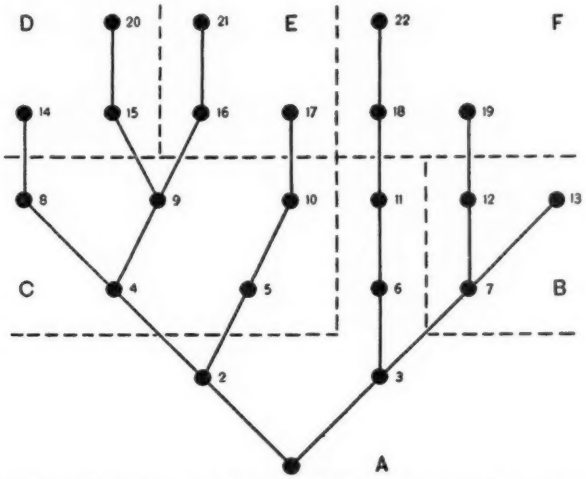

FIG. *1*—Diagram of a hypothetical expanding population genealogy showing species foci of six consecutive species generations and their possible grouping into genera.

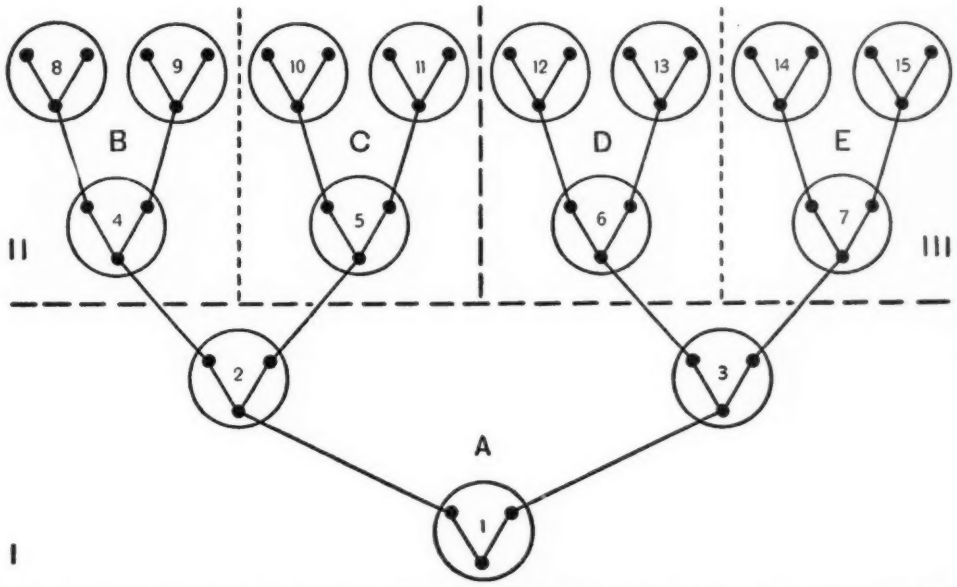

FIG. *2*—Diagram of a hypothetical expanding population genealogy showing species foci grouped in Class 1 genera and their possible classification into families and orders.

Some systematists, in concession to practicality, are prepared to recognize as proper any group that has descended from a single group of the next inferior rank. According to this idea a family may have descended from several species included within a single antecedent genus. Analysis shows that this proposal is potentially much more radical than has been realized. Certainly genera of Class 2, as defined above, would not be unacceptable.

the same in both of these figures and the genera have been combined into as many families and orders as possible without creating unnecessary monotypic groups. The species pattern seems to be quite different but this is more apparent than real because if intermediate species be introduced in figure 3 their pattern also becomes identical to that in figure 2 (see fig. 4) but the genera are differently constituted.

Similar diagrams might be prepared to

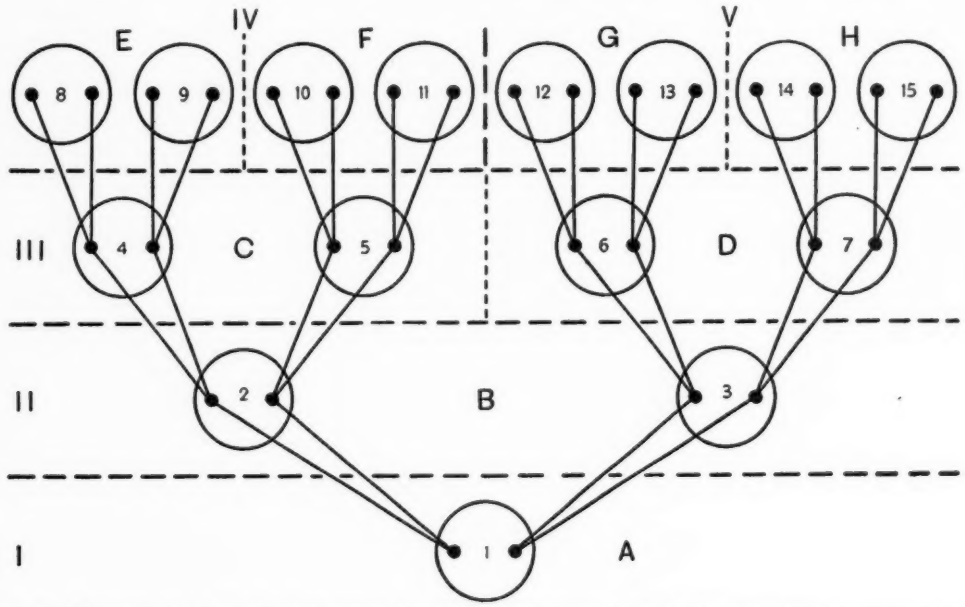

FIG. 3—Diagram of a hypothetical expanding population genealogy showing species foci grouped in Class 2 genera and their possible classification into families and orders.

If each group, however, may deviate from the ideal only to the extent of corresponding to Class 2, it is possible for the common ancestral species to be pushed backward one step for each grade in the taxonomic scale. For example, in figure 3, Order IV descended through Family C and Genus 2 from a species of Genus 1 and certainly it must be considered polyphyletic. In such a pattern, therefore, an order might have its ultimate origin in a species three orders removed.

The diagrams shown in figures 2 and 3 have been made as simple as possible and any number of intermediate species, genera, etc. might have been inserted in the various lines of descent. The pattern of genera is

show relations with genera of Classes 3, 4, and 5 but they would be complex and have little or no further significance in this discussion.

The foregoing abstract consideration leads to two conclusions. First, the manner in which species are grouped in genera may exert an unexpectedly strong influence upon a logical and consistent classification at higher levels. Second, even the slightest deviation of species grouping away from genera of Class 1 is certain to increase the tendency toward horizontal classification and the creation of polyphyletic taxonomic groups. The real point of all this is that the paleontologic record is so imperfect and the limits and relationships of most species

and genera are so uncertain that horizontal classification and polyphyletic groups in some degree, are unavoidable. If this is so, if horizontal classification is useful and convenient, and if other means can be provided to trace detailed phylogenetic relations, why should not certain taxonomic categories be recognized as frankly horizontal morphological groupings designed to meet the practical needs of paleontologists?

MORPHOLOGICAL GENERA AND FAMILIES

General paleontologists are mostly concerned with species, genera, and to a lesser extent with families. The basic problems of species are unrelated to higher taxonomic categories and have been considered briefly earlier in this discussion. Genera and families, however, are comparable except that they exist at different levels. Higher categories are necessary to complete the taxonomic structure, but they are of little importance in practical paleontology except as they affect the lower grades. Therefore, if genera and families were useful and stable groups the needs of most paleontologists would be best served.

I propose for consideration, therefore, that genera and families (and possibly the other higher primary taxonomic grades) be accepted as frankly morphological groups of fairly inclusive character. Many of them undoubtedly would be polyphyletic in some degree and they would exemplify an admittedly horizontal system of classification. This, after all, is the original manner in which taxonomic groups were understood and systematists are certain to emphasize that such a reversion to old concepts is reactionary and "unnatural." From one point of view this may be true but something that is new is not necessarily superior in every respect to something that is old. The superiority of one system over another is relative and depends almost wholly upon the objective that may be desired. Certainly the old morphological system of classification is more useful, practical and fundamentally stable although it may fail seriously in indicating phylogenetic relationships.

Such acceptance of genera and families as morphologically homogeneous groups so constituted that they could be reasonably

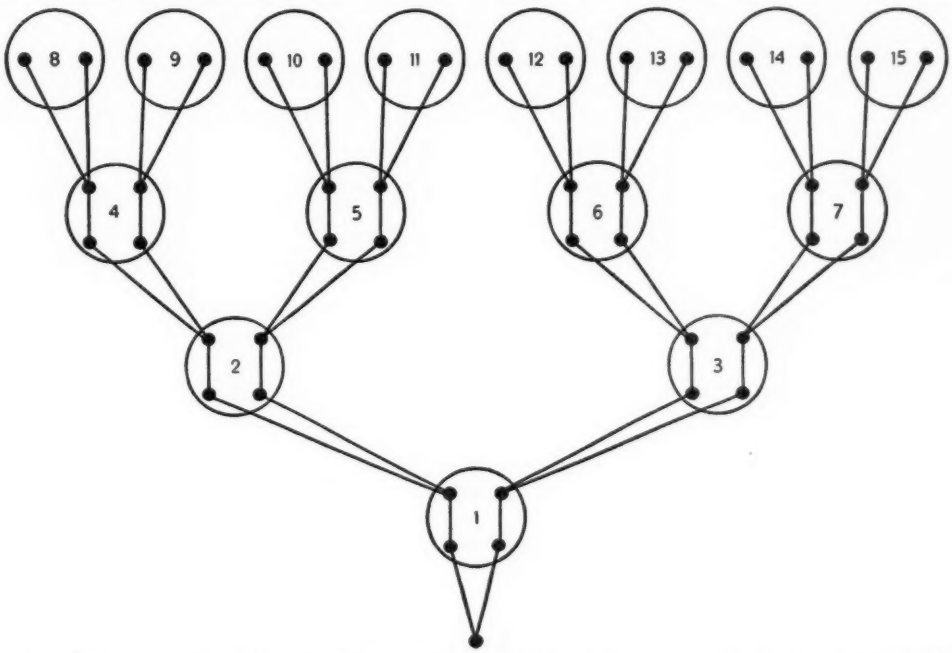

FIG. 4—Diagram produced by a different generic grouping of the species of figure 2 or by the introduction of intermediate species into the pattern of figure 3.

easily identified and, if possible, stratigraphically restricted, would furnish the basis for a practical and useful classification that is urgently needed. I do not intend to suggest, however, that phylogenetic considerations should be completely ignored. Many broad features of the phylogenetic pattern are generally recognized and these certainly should find expression in the classification. I do believe, however, that the practicality of the system should not be sacrificed to minor aspects of supposed phylogeny which are not well established. Nor does the classification need to be completely static, but an old and useful system should not be greatly modified or discarded until a better and equally useful one has been developed and will find wide acceptance.

The foregoing suggestion, as so far outlined, seems ideal from the standpoint of practical paleontology. However, it has one serious and clearly apparent deficiency. It does not provide convenient means for expressing the less evident and generally minor aspects of phylogeny and, as previously stated, I believe that investigations in this field are both worthy and important. Means should be provided, therefore within the classification to permit the ready delineation of possible phylogenetic relations in as great detail as may be necessary.

PROLIFICATION OF GENERA

Many paleontologists object to the creation of subgenera on the grounds that the taxonomic relations of subgenera to genera do not reflect the phylogenetic pattern as they see it. Consequently the number of new full genera proposed has been increasing in recent years at a constantly accelerating rate that gives no indication of leveling off. It is this increase in the number of generic names and the resulting changes in the names of many familiar and long established species that are so troublesome to all paleontologists outside of their own particular fields of specialization, and so confusing and discouraging to students. This, more than anything else, is at the root of the most apparent and troublesome type of taxonomic instability. I feel that the situation as it now exists is dangerous to the welfare of paleontology as a whole because the ever expanding maze of taxonomic detail and the multiplication and increasing instability of names discourage capable students from choosing paleontology as a field of research. Many regard activities that lead in this direction as senseless and essentially unproductive of any significant results, and they turn their attentions elsewhere. In order to progress, paleontology must attract imaginative and able new recruits. In my opinion the surest way to get them is to reduce taxonomic complexities to a minimum and greatly increase emphasis on the biologic aspects of paleontology which open the way to a whole series of practically virgin fields that cannot help but stir the imagination of anyone interested in living things.

The recognition of a great multitude of minutely discriminated genera has several serious practical disadvantages. Names become so numerous that it is impossible to keep track of them. I am reasonably acquainted with late Paleozoic invertebrates in general and with trilobites of all ages. Often, however, in scanning lists of fossils I find generic names that are unfamiliar even to the extent of my being uncertain as to the phyla to which they belong, and I think that all paleontologists must have similar experiences. Running such names to earth may be very difficult and time consuming, and not infrequently a strange name turns out to be an old acquaintance in disguise.

At present, also, the essential characters of many genera can be observed only in exceptionally preserved and consequently rare specimens. For example, in some of the families of inadunate crinoids generic discrimination is made on the basis of arm branching, but probably not more than one specimen in a hundred is found with arms attached and well preserved. Likewise, some genera of trilobites are based on the character of the hypostome which is rarely seen. This results in a somewhat absurd situation where it may be impossible to place an excellent and well characterized species or it may be necessary to arrive at a specific identification before it is possible to assign specimens to a genus.

Finally, the recognition of such closely discriminated genera places emphasis overwhelmingly on differences although similarities are certainly of equal importance. It

is not uncommon for the identifications of faunas, which are very closely similar in composition, to be expressed in such different terms that a spurious disrelationship is indicated and the true affinity may be apparent only to one who is intimately acquainted with all the names involved and also, perhaps, the idiosyncrasies of the identifying persons.

These disadvantages may not seem serious to the systematist or specialist who can ignore all matters outside of his chosen and restricted field, but they are of great importance to the stratigraphic paleontologist concerned with the identification of specimens, the comparison of faunas, and the making of correlations which is so essential to stratigraphy in its broader aspects. Paleontology is not the exclusive field of the paleo-biologist or systematist and the stratigraphic paleontologist is fully as important to paleontology as a whole. The stratigraphic paleontologist's horizon is necessarily much broader than the specialist's and he cannot be expected to have the intimate knowledge of all the specialists combined. If specialists desire to advance the cause of all paleontology, they should recognize that it is their duty to make their discoveries or conclusions as available, as understandable, and as useful as possible to others. These desirable objectives certainly are not advanced by the prevailing great increase in full generic names.

I do not mean to imply that the systematists and morphologists do unimportant work. On the contrary their studies are essential to well rounded paleontology and must continue as long as progress is to be made. However, I do not think that their work is of dominating importance, and I can see no valid reason why all paleontologists should be forced to accept a system of classification, even a phylogenetic one, merely because these persons may so desire. It seems unreasonable to me that paleontology should be expected to serve any system. After all there is nothing sacred about a system and the best is bound to be inconsistent and arbitrary in some respects. The system that is accepted should serve paleontology—not just one group of paleontologists, but paleontology as a whole—just as fully as any system possibly can.

If we should accept genera as more or less broad groups defined on the basis of morphology and do not demand too close adherance to strict phylogeny, a considerable degree of simplicity in classification and stability in nomenclature could be attained. Such genera could be split into as many and as minutely discriminated subgenera as specialists may desire and no group already recognized and named need be abolished. However, many current genera would be reduced to subgeneric rank. For all practical purposes these subgenera would be as useful units as the present genera. Through them phylogeny could be traced. Specialists could manipulate them at will to express their new discoveries or their differences of opinion. Such activities, doubtless of great interest and importance to a few, could, however, be ignored by the many who are not concerned with such details. Non-specialists could by-pass these minor or unstable groups and continue to deal with familiar species (although these might be more finely discriminated) and genera. Names would not change so frequently and a *Spirifer* would remain a *Spirifer*.

CONCLUSIONS

It seems absurd to me that we should adopt a code of complicated rules in order to achieve nomenclatural stability and then surrender to a system of classification that makes stability impossible. If it is reasonable to demand stability in one direction, why is it not reasonable to desire it in the other? For practical purposes this problem must be faced because we are rapidly approaching an unmanageable situation which is bound to react unfavorably upon paleontology as a whole.

I think that my suggestions may furnish a workable solution. They provide, in effect, a dual classification in which genetic units are subordinated to frankly morphologic ones. The total pattern, however, conforms to the conventional system of classification and no sharp break with custom or tradition is necessitated. Some persons are certain to object on the grounds that this is a reactionary step. I can understand their viewpoint, but I think that such a change would actually be progressive. Although phylogeny might be required to take a secondary posi-

tion in the system this does not imply that its significance is belittled. This shift in emphasis would only show that we recognize the necessity of making some concession to practicality and are facing the problem realistically. Adequate means for expressing detailed phylogenetic relationships are furnished and intolerant systematists have nothing to lose but a sense of their own importance.

So far I have stressed the advantages that I see associated with a more practical system of classification, but before closing this discussion it is necessary to acknowledge that some disadvantages are also inherent to it. For instance, the reduction of many genera to subgeneric rank would undoubtedly create homonyms and require the introduction of new specific names which would disturb stability of nomenclature temporarily. More serious, perhaps, from the systematists' standpoint, would be the possibility that phyletic lines might cross and different parts (subgenera) of a morphologic genus might be assignable, on a strict phylogenetic basis, to different families. Such relations, however, are likely to be largely matters of opinion and subject to various interpretations, and it is because of this that modern classification is increasingly unstable or has broken down completely. Consequently, it is my conclusion that these and other possible disadvantages are secondary in importance to the very distinct advantages offered by a more practical system of classification.

Even though we may agree that a simpler classification with a reasonable degree of stability is desirable and that this might be achieved along the lines of my suggestions, the establishment of such a system would be no easy matter. First of all, many paleontologists must recognize a new objective. They must transform themselves from splitters, not to lumpers, but to builders. Instead of creating new genera from old ones, they must build subgenera into useful genera. This should prove an inspiring challenge to their knowledge and judgment, for a good job of building is much more difficult than tearing down, and great credit and the gratitude of all paleontologists would be well earned by him who accomplishes it satisfactorily.

JOURNAL OF PALEONTOLOGY VOL. 23, NO. 6, P. 691, NOVEMBER 1949

PALEONTOLOGICAL NOTE

HINGE MECHANISM OF PALEOZOIC OSTRACODES[1]

I. G. SOHN[2]
United States Geological Survey

In studying the hinge elements of straight-backed Paleozoic ostracodes, the writer observed that opposing valves of specimens of the same species have hinge elements that cannot possibly "key" into each other when the carapace is intact. This note proposes an explanation of this anomaly.

The valves of living ostracodes are attached to each other at two areas by means of two distinct elements: (1) a ligament along the dorsal margin, and (2) adductor muscles, the ends of which are fused to the shell at approximately the middle of the valves (muscle scar area). The adductor muscles close the valves, and the ligament keeps the valves open.

The writer observed that living freshwater ostracodes open the valves very slightly in order to extrude the appendages; the angle between the open valves is small, on the order of 5° to 10°.[3] This angle probably varied with different groups of fossil ostracodes, depending upon the amount of overlap along the ventral margin, but probably was always so small as to require very little movement at the fulcrum along the hinge lines when the valves closed.

It is postulated that the ligament performed a dual function: it connected the two valves, and it acted as an elastic medium that was compressed when the valves closed. Relaxation of the adductor muscles released the pressure on the ligament and caused the valves to open. The groove and flange elements that compose the hinge structure of many groups of Paleozoic ostracodes served in part as a fulcrum and in part to strengthen the attachment of the ligament to the valves. Consequently, they did not necessarily "key" into each other. Cardinal teeth and sockets had the function of preventing lateral movement of the articulated valves.

The writer wishes to thank Dr. C. L. Cooper, U. S. Geological Survey, with whom this concept was discussed and who read this manuscript. Dr. Cooper had arrived tentatively and independently at a similar conclusion.

[1] Published by permission of the Director, U. S. Geological Survey.

[2] U. S. Geological Survey, Washington, D. C.

[3] Confirmed by Miss J. M. Berdan, U. S. Geological Survey, written communication, December, 1947.

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ERRATA

For: S. W. Tromp, The value of Globigerinidae ratios in stratigraphy, Journal of Paleontology, Vol. 23, no. 2, pp. 223–224, March 1949.

p. 223, right hand column, line 12 from bottom:
ratios, for rations

p. 224, left hand column, line 10 from bottom:
Globigerinoides, for *Globigerinella*

p. 224, right hand column, line 10 from top: from the Middle to the Upper *and* to the Lower

p. 224, right hand column, line 15 from bottom:
Geologie *en*

For: Kiyoshi Asano, New Miocene Foraminifera from Japan, Journal of Paleontology, Vol. 23, no. 4, pp. 423–430, 2 text figures, July, 1949.

p. 423 line 6 from bottom: (Fig. 1, *nos. 61–64*) should read (Fig. 1, *nos. 61–65*).

p. 424 line 4 from top: (Fig. 1, *no. 1*) should read (Fig. 2, *no. 1*).

p. 424 line 27 from bottom: (Fig. 1, *nos. 18–20*) should read (Fig. 2, *nos. 18–20*).

p. 424 line 21 from bottom: (should read *Globobulimina pacifica Cushman* (Fig. 1, *no. 60*).

p. 426 left hand column line 10 from top: should read Figure 1, *nos. 61–65*

p. 426 right hand column line 3 from top: should read Figure 1, *nos. 4–11, 20, 21.*

p. 426 line 6 from bottom: should read *47—Virgulina cf. pauciloculata Brady*

p. 426 bottom line: should read *61–65—Pseudogaudryina ishikiensis Asano*

p. 426: Add to explanation of Figure 1
49—Lagena substriata Williamson, ×30. (p. 424).
60—Globobulimina pacifica Cushman, ×30. (p. 424).

p. 428 right hand column line 12 from bottom: should read Figure 2, *nos. 23–27*.

SOCIETY RECORDS AND ACTIVITIES

TWENTY-FOURTH ANNUAL MEETING OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

Stevens Hotel, Chicago, April 24–27, 1950

The annual meeting of the S.E.P.M. will be held at the Stevens Hotel, Chicago, on April 24, 25, 26, and 27, 1950. As in previous years the meeting will be held jointly with the A.A.P.G. and S.E.G.

S.E.P.M. TECHNICAL PROGRAM

In addition to presidential addresses and joint sessions with the other two exploratory societies, the S.E.P.M. program will include technical sessions and a symposium. The symposium, under the direction of the Research Committee, will be on Problems in Marine Geology and will include papers by outstanding authorities.

President Stenzel has appointed L. L. Sloss, Northwestern University, Evanston, Illinois, to be program chairman for the S.E.P.M. Members planning to submit papers should notify the program chairman by January 1st of the title and length of their papers. Abstracts, typewritten, double-spaced, and in duplicate, are due on or before February 1st.

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